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Side Port Furnaces

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• THE SIDE PORT FURNACE occupies a place in the glass industry for the most economical production of large volumes of glass. Its application to the industry is varied, covering the production of pressed and blown ware, tubing, drawn sheet, rolled plate and other glasses. Furnaces for such glasses, range in size from approximately 300 square feet to as much as 2500 square feet of melting area.

Such furnaces are conventionally designed based on an output rating in square feet of heat exposed area per ton day. The melter area normal rating for various type glasses falls over a wide range based on the nature of the raw materials and the end product requirements. Some examples are:

Container furnaces are conventionally rated at from 4 to 6 square feet per ton;

Plate glass furnaces from 4.5 to 6 square feet per ton;

Sheet glass furnaces from 8 to 12 square feet per ton;

Borosilicate glass furnaces will melt on 8 to 20 square feet of melting area depending on the ultimate use of the glass.

Further furnace differences are dictated by the type of glass being made. These variations can be broken down into two major categories. Bridge wall type furnaces wherein the melting end is separated from the refining chamber and interconnected by means of a throat only, and those in which the melting end and refining end are not separated, such as used for producing plate and sheet glass.

When the area of the melter required becomes large, side firing is the most feasible means to provide the proper distribution of heat release down the length of the furnace hearth. With the advent of the metallic recuperator, which overcomes many of the problems experienced with refractory type installations, furnaces of small and medium areas can now be fired from the side to obtain a controlled heat release distribution in an economical manner. These applications are reasonable on furnaces which would require as much as 50,000 CFH of 1000 BTU's natural gas when direct fired.

Side port fired regenerative furnaces fill the requirement of controlled distribution with the greatest gain in heat recovery. The expenditures involved in these furnaces confront the designer with the requirement of effecting maximum heat transfer to the glass and high waste heat recovery within economic limits.

There are many elements to be considered in designing for economy. Some of the major items being building space and expenditure, fuel consumption per ton of glass produced, refractory costs and construction costs.

This paper will be limited to certain considerations involving principles of efficient fuel application, touching on some of the other elements when appropriate.

Fuel Consumption

Any approach to fuel application must be preceded by the determination of the amount of fuel required and the type of fuel to be burned.

This determination is based upon the type of glass to be made and the furnace conditions required to do so. The furnace conditions dictate the amount of heat required for holding heat or "Idle Load" and the glass to be produced determines the "Glass Load."

The greatest percentage of fuel requirement is that necessary for "idle load" to maintain the operating temperature. This idle load is a function of the com-

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bination of the furnace temperature, refractory structure, age, fuel thermal efficiency and size of melting area. For all practical design purposes, the following basic data is sufficient.

Figure 1 illustrates the amount of holding heat required per square foot of melter area in the container or bridge wall type furnace at the temperature of 2632°F. This curve was prepared by Schwalbe from analysis of conventional furnaces reduced to average conditions. You will note that as the melter size increases, the amount of fuel required to maintain melting temperature per square foot of area decreases. This is due to the larger area of glass exposed to the furnace *atmosphere and refractory radiation*, in relation to the exterior furnace surfaces available for the loss of heat through radiation and convection to the surroundings.

The holding heat illustrated must be corrected for furnace temperature, age and refractory structure. Fig. 2 indicates the various factors which must be applied to the original values obtained from Fig. 1. Much work has been compiled and published regarding the determination of the fuel requirements and the evaluation of furnace performance based on fuel consumption which may be referred to for more detailed analysis.

To the "idle load" requirement must be added the heat to the glass produced or the "glass load." With this information, the designer is in a position to approach the problem of the most economic means of fuel application.

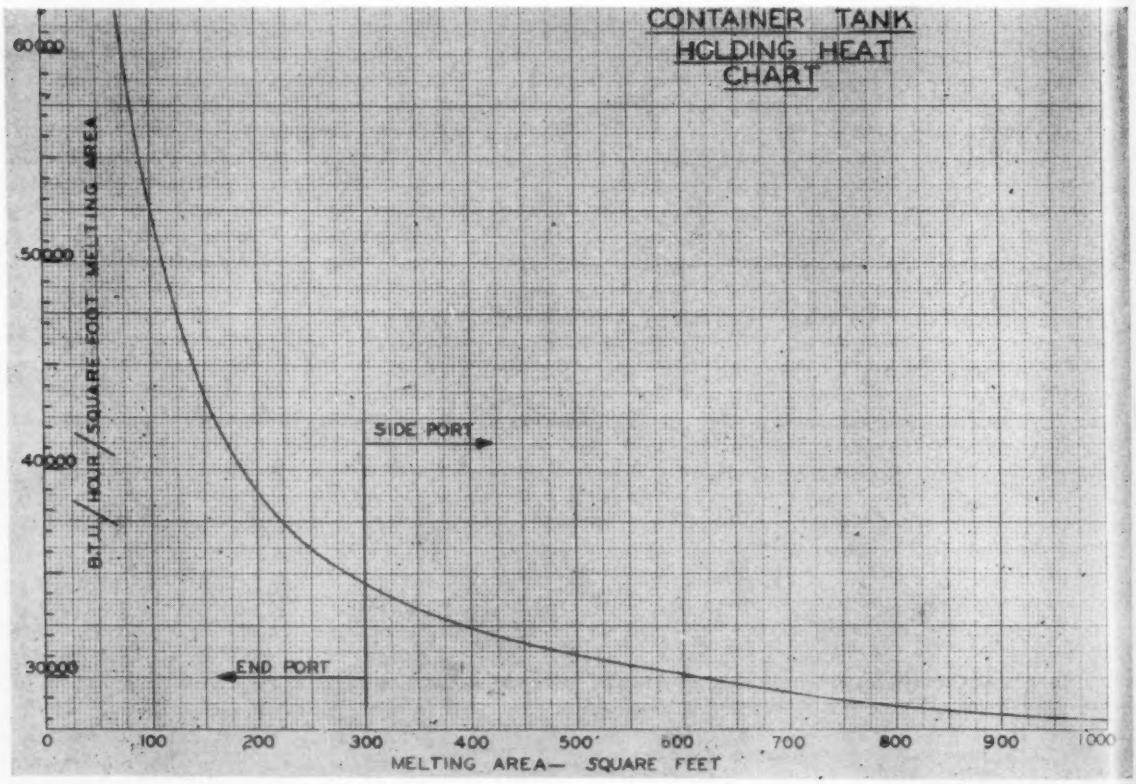
Since the melter size is determined by the amount and type of glass to be produced, the major economy approach available to the furnace designer is to increase the amount of glass produced per square foot of surface area. The super refractories have made it possible to utilize higher melting temperatures, thereby permitting increased tonnage output for a furnace of a given size. However, as shown in Fig. 2, these refractories and higher temperatures have increased the amount of holding heat required. These conditions invite the investigation of every advantage available in the application of heat release and waste heat recovery.

Theoretically, if all BTU's could be released at the operating temperature, and over the entire surface of the glass in the proper amounts per foot of furnace length, the ultimate could be obtained in heat transfer to the glass. This would be approaching a point relative to perpetual motion, which is merely defined but never accomplished. We must be content to strive toward overcoming the economic limitations of waste heat recovery and the physical limitations of furnace construction.

Waste Heat Recovery

The major limitation placed upon us is in obtaining maximum heat recovery through regeneration. The cost of additional checkers is not only found in the refractories and labor, but in the initial costs of building space, excavations and foundations. Therefore, checker volumes beyond a definable point do not justify their cost based on the heat recovery remaining at low temperature differentials.

Fig. 1



It privileges the designer to choose the checker material and arrangement to give the most economical results from heat transfer rates, surface exposed, life expectancy and temperature remaining in the stack gases. In view of the large volume of data published in regard to regenerative heat transfer, this paper will not attempt to cover any particular basic data.

The highest preheat of air through adequate regeneration reflects itself in increased flame temperatures. These increased flame temperatures affect the fuel requirement. They are also necessary in producing the high temperatures required for maximum production in a given furnace.

An increase of each 100° F preheat to the combustion air increases the theoretical flame temperature 48° to 68 F when burning natural gas. The temperature increase is dependent upon speed of combustion and heat abstraction during combustion. For practical purposes,

Fig. 2

To the values obtained from Fig. 1, add 15 to 20 per cent to the holding heat, if Corhart lining is used in tank sidewall in place of flux.
Add 30 per cent to holding heat if Corhart is used in both tank sidewalls and bottom in place of flux.
If the holding heat is any temperature other than 2632°F., use the following correction factors.

Holding Temp.	*Correction Factor*
3080°F.	1.373
2992°F.	1.289
2907°F.	1.214
2817°F.	1.140
2767°F.	1.110
2632°F.	1.000
2582°F.	0.965
2452°F.	0.880
2387°F.	0.839
2267°F.	0.769
2187°F.	0.725
2097°F.	0.678
2007°F.	0.633

the lower figure of 48° F closely approximates the temperature increase attained in glass operation.

In conventionally designed side port furnaces, it has been found that approximately 14 to 17 feet of checker height is a practical consideration based on furnace load and operating conditions.

This depth of checkers must be balanced by the fuel savings and operating conditions obtained due to the expenditure necessary for such a regenerative installation.

To obtain these depths without resorting to deepening the basement at resultant high building costs, the box type of regenerator construction would be recommended. With this arrangement, checkers can be carried to within two feet of the top of tank blocks. This construction provides additional advantages through manifolding the exiting gases and the entering combustion air at the port necks. Handling the waste gases in such a manifold, instead of uptake ducts, decreases refractory wear, resulting in lesser replacement cost.

The box type regenerator construction results in increased initial furnace cost but normally repays this difference at the first cold repair.

For example: The following is an evaluation of materials and construction cost above the regenerator crown spring line of uptake type design and from an equal elevation of a box type design.

Using as a base the initial installation cost of a 4 port high production furnace, incorporating uptake design and typical refractories, the initial cost of a box type design would be 33 per cent greater when using the same type refractory materials by area location.

The usual repair cost of the uptake type at the end of a normal campaign is approximately 55.3 per cent of the base.

The usual repair cost of the box type is approximately 14.4 per cent of the base, or uptake type installation cost.

Totaling the percentage differences involved, we find that the uptake type regenerator costs 55.3 per cent additional to the base cost and that the box type regenerator costs 47.4 per cent additional to the base cost for two normal campaigns.

The difference between the two evaluations indicates a saving of 7.9 per cent of the direct materials and labor base expenditure by use of box type construction.

This saving is in addition to the increase of preheat obtained through additional checker depth without increasing building installation cost. The cost of checkers is not included in the figures since their value would be previously considered in economic preheat evaluations.

These percentage figures are based on a representative installation and each furnace requires consideration based on its specific conditions.

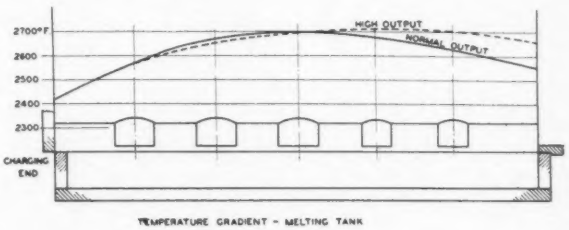


Fig. 3

In passing, I should mention the adaptation of box type regenerators requires that exacting determinations be made in port sizing for adequate fuel distribution down the length of the furnace hearth. In the uptake type, some furnaces still incorporate the use of dampers in the uptakes to control this distribution. Such adaptations are impractical in the box type construction and the designer must apply basic considerations to the sizing of each port.

Fuel Distribution and Application

Fuel distribution and application is dependent upon the type of glass, production load and other factors. However, in all cases, the major requirement is the uniform release over the width of the tank in the gradient per foot of length as dictated by the process. Side port furnaces provide the designer with the greatest flexibility in this respect.

Figure 3 indicates temperature distribution at average load by heavy line and at maximum load by dotted line for a representative furnace.

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G. C. M. I.

Glenn A. Mengle, Board Chairman, Brockway Glass Co., and new president of Glass Container Manufacturers Institute.

Left to right: A. J. Martin, Director of Labor Relations, GCMI; R. A. Blunt, Buck Glass Co.; J. P. Levis, Owens-Illinois Glass Co.; and H. C. Herger, Pierce Glass Co.

J. E. Bellinger and E. F. Ball, both of Ball Brothers Co.; and V. L. Hall, GCMI general manager.

• GLENN A. MENGLE, chairman of the board, Brockway Glass Co., was elected president of the Glass Container Manufacturers Institute during the 3-day meeting at the Greenbrier, White Sulphur Springs, West Virginia, from May 21 to May 23. He was president of the Brockway Sales Company from 1927 to 1933, when he became executive vice president of Brockway Glass Company. He was named Brockway president in 1949, and chairman of the board two months ago.

F. N. Dundas, executive vice-president of the Dominion Glass Co., Ltd., became GCMI first vice-president, and C. G. Bensinger, executive vice president of Owens-Illinois and president of that company's Glass Container Division, was elected second vice-president.

Mr. Bensinger became a member of the GCMI board of trustees, succeeding W. J. Green, president of Thatcher Glass Manufacturing Co., who has completed his term.

Also elected to the board of trustees were S. B. DeMerell, vice-president of Anchor Hocking Glass Corp., and J. F. Wiley, a board member of Tygart Valley Glass Company.

Outgoing officers were E. F. Ball, Ball Brothers Co., as president, and J. S. Heuisler, Maryland Glass Corp., first vice-president. Mr. Heuisler withdrew from active office in GCMI following an automobile accident and is now convalescing.

Departing from the usual schedule of previous years, the committee meetings were held on Tuesday, May 20, instead of on Monday. This revised program was followed in order to avoid conflict with the Greenbrier's Spring Festival and Golf Tournament which immediately preceded GCMI.

Spring Meeting

Golf Committee: R. E. Graham, Owens-Illinois Glass Co.; K. C. Frazier, Olin Mathieson Chemical Corp.; and J. E. Bellinger of Ball Brothers.

Ladies Committee, left to right, Mrs. E. M. Lawrence, Mrs. I. H. Munro, Mrs. R. M. Ulmer and Mrs. A. L. Bernardin.

The standing committees of the Glass Container Manufacturers Institute delivered their semi-annual reports. Glenn Mengle discussed the work of the Market Research and Promotion committee; R. L. Cheney, R. B. Shirey and Bush Barnum outlined the 1958 GCMI Marketing and Advertising program; A. F. Huni reported on the Traffic Committee; A. J. Martin, on Labor Relations; and F. H. Wright issued the report of the West Coast Manager.

J. G. Turk spoke on the Package Design and Specifications Committee, while F. H. Dellwo and L. G. Ghering described the work of the Committee on Testing Procedures, and S. L. Rairdon and H. W. Kuni reported on the Subcommittee for Public Education.

On May 22, the group responsible for developing the new *Glass Container Industry Research Corporation* met to discuss various aspects of their research program. The purpose of this organization is to study technical problems, and conduct research, in the glass container field.

Mr. and Mrs. Howard C. Herger of Pierce Glass Co. gave a cocktail party for GCMI members which was enjoyed by every one.

The golf prizes were distributed immediately after the business session on Wednesday, with 63 winners in all.

Roger Hetzel won the 1st Low Gross; Fred Dundas, 2nd Low Gross; L. G. Ghering, Longest Drive; Sid Davis, Closest to the Pin; F. P. Boehm, High Gross for the 1st nine holes; and I. R. Macdonald, High Gross for the 2nd nine holes.

The Fall meeting of the Glass Container Manufacturers Institute will be held at the Cloister, Sea Island, Georgia, from November 10 to 13.

Talking over the golf tournament, left to right, are, C. R. Megowen, president, Owens-Illinois Glass Co.; W. S. Coffman, sales manager, Foster-Forbes Glass Co.; V. L. Hall, GCMI general manager; and R. L. Cheney, GCMI executive director and marketing manager.

Eighth Overmyer Iron Clinic

• NEARLY 140 PERSONS attended the Overmyer Iron Clinic on June 5 at the Overmyer Mould Company, Winchester, Indiana. They registered at the Omco office before taking the factory and foundry tours, during which they viewed the latest in mold manufacturing and foundry production methods. Later, the group gathered at the American Legion to see metal displays and to participate in the technical portion of the program.

Lowell Roesner, president, Overmyer Mould Co., welcoming glass industry representatives to Eighth Overmyer Iron Clinic.

The welcome address was made by Omco President, Lowell Roesner, who said that facilities and personnel of the organization were available to make the day as profitable as possible for everyone.

Mr. Roesner temporarily digressed to comment briefly on past, present and future prospects of the Industry. He mentioned the fabulous growth enjoyed by the Industry which put glass container shipments beyond the twenty-billion mark for the first time during 1957.

Glass container and closure sales also enabled the industry to climb into the billion dollar category for the first time. In this connection he stated: "The efforts of men present here today, and others who are constantly looking for better methods, are largely responsible for the progress and subsequent growth of the glass manufacturing industry.

"New records will be established in the future and will be made possible only by creative ideas born in the minds of individuals, and carried to fulfillment by you men. It is with great satisfaction that I identify myself and the Overmyer Mould Company with one of our country's most dynamic industries."

Mr. Roesner introduced Omco Vice President, Earl R. Flatter, who acted as moderator for the technical portion of the program. The format practiced with good success in previous years was used once again. The lecture type of program was condensed to short discussions to allow audience participation.

Introduction to Mold Metals

Mr. Flatter spoke generally on the new foundry expansion program, and more specifically, on the electric induction furnaces installed during the latter part of 1957. At this point he introduced Omco's Chief Metallurgist, Newton Davis, who described the complete foundry program to preface his remarks about the new electric furnace facilities. He began his talk with a general classification of cast irons.

Classification No. 1. Standard gray irons are classed according to their ultimate tensile strength in a range from 20,000 to 60,000 PSI minimum. Applications involving moderate corrosion, heat resistance, and wear make this type of iron satisfactory. Today's mold metals demand more than the traditional cast iron can deliver.

Classification No. 2. Alloyed cast irons properly identify Omco mold irons sold under the trade name "Omiron No. 1, 2 and 3." These irons have been altered by changing the chemical composition through the introduction of nickel, chromium, molybdenum or vanadium. The result is an excellent mold iron that is corrosion resistant, heat resistant, and wear resistant. It also has low thermal expansion and does not possess non-magnetic properties.

Classification No. 3. Ductile or Nodular type iron is the final classification which brings the discussion to the purpose of the electric induction furnaces. The principal product produced by these facilities is nodular iron sold under the trade name "Omnod."

From a very modest beginning, Omnod today is sold in such quantities that it has become necessary to estab-

Earl R. Flatter, vice president, Overmyer Mould Company, who was moderator of technical discussion.

lish separate facilities for the production of nodular iron. The new electric furnaces will increase the total volume of mold metals and, most important, a more strict control will be possible over each heat. Complete quality control is now better accomplished and provides uniform castings, free from undesirable elements.

Omnod is a superior, high-strength cast iron with a relatively high carbon content. Some of the qualities are:

1. Heat treat response is good, relieving internal stress caused by various portions of the casting cooling at different rates.
2. Dimensional stability is better retained at elevated temperatures than with other types of cast iron.
3. Scaling conditions at high temperatures are minimized.
4. Thermal shock and subsequent cracking under ultimate heating and cooling is greatly reduced.
5. Hardness range is much greater and approaches that of steel.
6. Castability of metal is superior, providing complete detail of thin and complex sections without internal defects.
7. Machinability is an arbitrary measure of the relative ease of cutting a metal. Although nodular iron is higher strength and develops a greater hardness than other conventional mold irons, it must be remembered that there is no consistent relationship between hardness and machinability.
8. Wear resistance of nodular iron is good in metal-to-metal, or frictional wear, and abrasive wear.
9. Lubricant response of metal is better under actual production conditions.
10. Corrosion resistance of nodular iron is greater than that of other types. It should, however, be emphasized that proper handling and storage practices can minimize the deteriorating effects of rust.
11. Dampening qualities (ability to absorb vibration) are outstanding, thereby relieving stress levels.
12. Weldability of nodular iron does not vary greatly from other cast irons. Two common characteristics of both materials are rigidity and high-carbon content. Therefore, the stress and growth characteristics are essentially the same when preheated to ensure uniform expansion.

At this point it might be well to mention that Omnod (nodular iron) is not a cure-all for all the ills of the glass industry. It is, rather, a definite advance towards this objective. Our progress to date in metals research can be attributed to the technicians of the industry who have made their problems known and have worked with the Omco organization to create a better working tool. The result is a better glass product and progress for the glass industry.

Observing T-D Amerseal Ring Threader, left to right: Richard Benson, operator, and Bill Davis, both of Overmyer Mould Co.; Harry Semans, Armstrong Cork Co.; Elvin Rector, Foster Forbes Co.; Earl Wilson, Armstrong Cork; Gene Henrie, Universal Glass Co.; and Perry Surber, Foster Forbes.

The discussion of Omnod was climaxed by questions from the floor concerning various applications of this unique metal.

Chromalloy

The next item on the agenda was the introduction to the Chromalloy process which is still in the research and development stage. Mr. Flatter opened his remarks by saying, "Many of you over the years have tried every conceivable form of chrome plating. Your skepticism of any form of plating is justified because of many disappointing experiences. Therefore, I must explain that Chromalloy is not just another plating process."

Chromalloy is a patented chromizing process. In contrast to an applied plate the chromium is actually diffused into the surface of the iron to create a metal more resistant to corrosion, heat and wear than the original

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More than 140 industry representatives attended the 8th Overmyer Iron Clinic at Winchester, Indiana.

Donald E. Sharp

Pacem aeternam dona eis, Domine

Donald Sharp was one of the technical editors of THE GLASS INDUSTRY from 1930 to 1931. The other was myself. It was a happy association, ended by the increasing illness of George Cooper, the owner and editor-in-chief, who finally sold the paper to Ogden-Watney and retired to live until his death with his sister in Canada. Don was born October 30, 1896 and died March 29, 1958. His death came as a sudden shock to most of us, though not, as now appears, to his physician. As Francis Flint said "This is getting very close to home". Jess Littleton commented: "Don entered the glass industry by becoming my personal assistant, and he was the best I ever had." From George Morey, John Hostetter, and many others and from Wilf Hampton in England came other comments, terse and poignant, as though no one dared to express himself fully, for the nearer the heart the fewer the words. He was younger than most of us: indeed I think he might be held to be the youngest of the original band of pioneers of glass technology in America, and almost the first to go. Glass technology has suffered a sudden setback. We lose not only a well-loved personality with an exceptional knowledge of the history and development of the industry, but we probably lose also that treatise on the physics and mechanics of melting furnaces that he had been struggling for years to perfect.

"Lo, some we loved, the kindliest and best,
Whom rolling fate of all their vintage pressed,
Have drunk their cup a round or two before,
And one by one passed silently to rest."

The terse biography that appears in American Men of Science gives the standard vital statistics of his career: his scientific papers are available in the journals of glass technology and in THE GLASS INDUSTRY: we are concerned here only with the man as we knew him, with the hunter and fisherman, the man of business, the musician and humorist, the champion of those whose merit was going unrecognized, the warm-hearted friend.

Born in Corning, Don was a classmate of J. S. Gregorius at Corning Free Academy. They both graduated in 1913 and both took pre-college employment at Corning Glass Works. Don was in the Physics Department as personal assistant to Dr. Littleton: Joe was assistant to the chemists, Dr. Sullivan and W. C. Taylor. Their work week was six days, of ten hours each. On Saturday their principals would have the afternoon off, and the two juniors used the opportunity to make not only the experimental ones assigned to them, but a great variety of others of strange compositions of their own concocting. There was apparently much friendly rivalry between the Chemistry and Physics Departments, in the persons of the two young men, but they learned much of glass compositions and properties and of the value of teamwork between different disciplines.

Don left Corning to enter the University of Wisconsin, where he acted as lecturer assistant, a position that partly defrayed his university expenses.

Don was not born with any silver spoon in his mouth, but he was very fortunate in his early associations. With Littleton he could hardly avoid getting some very good ideas about the physics of glass. Not long afterwards, leaving the University of Wisconsin, he became Dr. Morey's assistant in the study of optical glass making at the Spencer Lens Company's plant at Hamburg, New York. That would make it virtually impossible to avoid learning a lot of physical chemistry.

In 1929 he associated himself with James Bailey in the incorporated firm of Bailey & Sharp, and must thereby have learned a lot about engineering and engineering physics. The firm operated from 1929 to 1937, through the worst depression in American history, and Jim gives Don the credit for guiding their Company successfully through it all.

In 1937 John Hostetter, who had become Director of Research of Hartford Empire in the reshuffle produced by the merger of Macbeth Evans with Corning Glass

Works, persuaded both Sharp and Bailey, together with Aaron Lyle, to join him at Hartford, and Don became Hostetter's immediate assistant.

Don's last major move was to Libbey-Owens-Ford at Toledo, which in a sense re-established the early keen, though friendly, rivalry with Gregorius, for the latter had for a generation been glass technologist to Pittsburgh Plate and now Don was chief glass technologist to Pittsburgh Plate's chief competitor.

And I do not doubt it reproduced some of the earlier thrust and parry and repartee, but the two retained to the end a deep liking and deep respect for each other.

At Libbey-Owens-Ford I think Don's association with the late Dave Goodwillie, formerly chief engineer of the Edward Ford Plate Glass Company, and later vice president of Libbey-Owens-Ford, was a happy one in most respects. I got the impression that after Mr. Goodwillie's death, things were, for a time, much less to his liking, and this, in combination with his own declining health and the complete incapacitation of his wife, Harriet, placed a tremendous physical and phychological load on him for the last few years of his life.

By this time he had become a business man and an administrator of consequence; he managed a large estate for his aunt in Pittsburgh, represented his firm in the Institute of Silicate Research at the University of Toledo, and was involved in other projects. He might very well have been president of the American Ceramic Society, but he discovered by experience thirty years earlier that the financial expense of being even vice-chairman of the Glass Division was more than a small firm like his own could stand and he therefore asked to be excused from being promoted next year to chairman. Littleton had told me earlier how much it cost Corning Glass Works when he, Littleton, was chairman and was trying to put the Glass Division on its feet. But other distinctions came Don's way, and among other things Lafayette University made him an honorary D.Sc. Dave Goodwillie, as I recall it, was still living at the time and told Don a salty story of how an honorary D.Sc. was once bestowed upon a horse.

The early close association of Don with Jess Littleton was not confined to glass technology, for both of them were mighty hunters before the Lord. When the raccoon-hunting season came around I think they must have spent most of the night in the woods. Don used to chuckle as he told me how they toiled all one night and got nothing, till the dog decided that a skunk would have to do, and as a result all three of them became highly odoriferous. They were also very hungry, and the problem of how they could get into the only restaurant in Corning that was open in the wee sma' hours looked formidable in view of the effluvium. It was solved by a very clever, but very simple stratagem, which Don credited entirely to Jess. They ate well, while the other guests commented how strangely the odor persisted without having any idea why.

In later years, after he moved to Toledo, I think Don got his deer most years in the woods of northern Michigan. I think too that he was a pretty fair hand as a fisherman.

When Professor Sparks first brought word to the Glass Division of how he had discovered the original Jamestown glass furnace in the woods of Virginia, Don was one of the most interested. He had told me much earlier that he was trying to assemble a complete library on all things relating to the history of glass manufacture and to its technology. Later, when Sparks became incapacitated, Don went to great trouble and a vast expenditure of time to try to make out from Sparks' rambling writings just what the facts were about the discovery of that furnace, a furnace that has figured greatly in the recent celebrations at Jamestown. The attempt was abortive, Sparks' writings being apparently incomprehensible; but believing as he did, and as J. C. Hostetter, Francis Flint, Henry Blau, and many others did, that Sparks' share in the rediscovery of the furnace had been underrated, he was instrumental in getting the American Ceramic Society to recognize formally that it was through Sparks that they became aware of it.

This was characteristic of Don: he was prepared to make great efforts on behalf of those he felt had been overlooked or underrated, and a number of people who received belated recognition, owe it, though they do not know it, to Don.

His friendship with American glass technologists were not casual business ones: there was a warmth and intensity about them that was unusual, and this extended beyond the U.S.A. His friendship with Hampton in England, for instance, was far more than a mutual interest in the misbehavior of glass furnaces. During the battle of Britain in World War II, before America entered the war, when shreds of human flesh were hanging on the telephone wires and houses were flattened by the acre, Hampton arranged that if both he and his wife should be killed, their younger daughter would, if possible, escape to America and be brought up by Don and Harriet: and the Sharps gladly accepted the responsibility, though they never had to exercise it.

His library went to Libbey-Owens-Ford. Hostetter, after his own incapacitation, found the mere packing of his own library a heavy task, and urged on Don that he get rid of *his* while he still had the strength to deal with it: and Don took his advice.

To many Don is known for his interest in music. He was a cello player of professional status. I think he financed a substantial part of his college education by that instrument, and he was a member of the musicians' trade union to the end, though he did not need the remuneration. He recited to me a parody on Gilbert and Sullivan's Tit-willow song from "The Mikado" with a sly dig at the feather-bedding practices of its dictator:—

> On a tree by a river a little Tom-tit
> Sang "Willow, Tit-willow, Tit-willow",
> While beside him in silence another bird sat
> By order of James C. Petrillo.

The last time I heard Don play was some time after World War II, when Toledo mourned its war dead, and at the Toledo Art Museum the Toledo Symphony Orchestra played a great Requiem, a solemn mass for the dead,

> . . . et pacem aeternam dona eis, Domine . . .
> and give to them eternal peace.

Good night, sweet prince; And flights of angels sing thee to thy rest! We who have yet to die salute thee: Morituri te salutamus.

F. W. PRESTON

DECKER NAMED CORHART BOARD CHAIRMAN

William C. Decker, president of Corning Glass Works, was elected chairman of the board of directors, Corhart Refractories, on June 10. He succeeds Frederick C. Thompson who will continue as a director.

William C. Decker

Following the directors' meeting, Dr. Gordon S. Fulcher was honored by Corning. Dr. Fulcher, an economist in Washington, D. C., invented the Electrocast process of manufacturing refractories while associated with the Corning Glass Works research laboratories. He was director of research at Corning for many years.

NEW PLANT FOR WALSH REFRACTORIES

Walsh Refractories Corporation is going to construct a new plant for the exclusive manufacture of fusion cast refractories for use in the glass manufacturing industry. The million-dollar plant will be located on the company's St. Louis property at 101 Ferry St. and is expected to be in operation by early 1959.

It will include an electric furnace, mold room, core room, batching facilities, annealing section and raw material and finished product storage.

KLEINER 50 YEARS WITH IMPERIAL

E. C. Kleiner celebrated his fiftieth year with Imperial Glass Corporation on June 16. During this time he has held almost every job in Imperial's factory and office, except in the actual production work. He now concentrates on special accounts in the New York area, and certain accounts which distribute nationally for the company.

He has been known for a long time to almost every one in the handmade glass industry.

INSTITUTE FOR SCIENCE TEACHERS

A Summer Institute for High School Teachers of Science, to be held from June 30 to August 9, is being sponsored jointly by the Pittsburgh Plate Glass Foundation, Pennsylvania State University, the National Science Foundation and several Pennsylvania industries. The purpose of the Institute is to help meet the continued shortage of qualified scientists and engineers. It is being attended by high school science teachers who are seeking a program on a graduate level.

NAMED TO VITRO MFG. POST

Joseph J. Swigart, vice-president of Berkshire Chemicals, Inc., has been appointed acting general manager of Vitro Manufacturing Company. He will retain his post at Berkshire Chemicals, which is a chemical sales subsidiary of Vitro Corporation of America. The Pittsburgh sales office of Berkshire has been transferred to the offices of Vitro Manufacturing Company at 60 Greenway Drive, also in Pittsburgh.

VISITS 1st SODA ASH PLANT IN HOLLAND

Raymond F. Evans, chairman and president of Diamond Alkali Co., took part in the official dedication of Holland's first soda ash plant on June 5. It is located at Delfzijl on the Eems estuary near the country's northern coast.

Mr. Evans presented to officials of the new plant a specially designed wall plaque handcrafted from aluminum and glass.

The Dutch plant, which was put on stream in December, 1957, with a daily productive capacity of 450 metric tons of soda ash, is based on a very extensive salt deposit (estimated at 20 billion tons) discovered shortly after World War II near Winschoten, some 20 miles away from Delfzijl.

WRITES CHAPTER FOR REFERENCE BOOK

Dr. Sherman S. Weidenbaum, senior chemical Engineer in the chemical services department, Corning Glass Works, has authored a chapter in a new reference book entitled, "Advances in Chemical Engineering." He presented a condensation of his work in June at the 50th annual convention of the American Institute of Chemical Engineers.

RECEIVE HONORARY DEGREES

George P. MacNichol, Jr., president of Libbey-Owens-Ford Glass Company, and Harold Boeschenstein, Owens-Corning Fiberglass Corp. president, were awarded honorary degrees by the University of Toledo at the annual Commencement last month. Mr. MacNichol received the degree of Doctor of Laws, and Mr. Boeschenstein, Doctor of Humane Letters.

L O F GLASS AWARDS CONTRACT

Libbey-Owens-Ford Glass Company has awarded the contract for its new Engineering Building at the Technical Center in Toledo, and is starting work immediately. The entire project should be completed in ten months, according to C. W. Davis, executive vice president of production.

The estimated cost of the project is $1,350,000, which includes alterations in the present Technical Building, extension of services to the new structure, and other necessary work and equipment.

PORTER UPS SILICA BRICK PRODUCTION

The Canon City, Colorado, Works of Refractories division of H. K. Porter Co. has increased its silica brick production more than 50 per cent with the installation of a new production unit. Three kilns have been redesigned to burn brick at higher temperatures required for higher quality products, and 31 major pieces of equipment have been installed, along with a modernized electrical system.

These facilities enable the plant to supply a new line of silica refractories for glass plants, and other industries, while previously this plant could produce only first quality Silica brick, made from local quartz, and fire clay brick.

Recent Translations of Russian Papers of Interest to the Glass Industry

Formation of porous glass

D. P. Dobychin and N. N. Kiseleva, (Russian) Journal of Physical Chemistry *32*, 27 (1958), studied the effect of heat treatment on this formation.

A glass containing 70 mol. per cent SiO_2, 23 mol. per cent B_2O_3 and 7 mol. per cent Na_2O was quenched from 850°C, then heat-treated, and finally extracted with hydrochloric acid. The volume V of pores in one gram of the resulting porous glass and the radius r of the most frequent pores were determined from the adsorption isotherms of water vapor.

It was found that V and r increased with the duration of heat treatment as long as the temperature of this treatment was below about 585°C. Thus, when glass was heated at 530°C for 0, 1, 24 or 384 hours the V of the porous glass after extraction with 3 N HCl at 50°C was 0.160, 0.171, 0.200 and 0.241 cu.cm./g., respectively, and the most frequent radius was 8, 16, 30 and 85 angstroms, respectively. The duration of the heat treatment required to achieve a pre-determined value of V or r was shorter the higher the temperature of the treatment (between 485°C and 580°C). As long as the heating temperature was below 585°C the volume V and the radius r depended also on the conditions of extraction with acid.

When the heating temperature was above 585°C, the values of V and r were independent of the duration of heat treatment and of the concentration of the acid used for leaching out, but depended on the temperature of heating. The effect of the heating temperature may be illustrated by the following example: a glass powder was heated for 108 hours at 600°C and another sample for 120 hours at 750°C, after which each was leached out at 50°C with 3 N hydrochloric acid; the V of the first sample was 0.202 cu cm./g. and of the second, 0.148 cu. cm./g.; and the r was 20 and 10 - 11 angstroms, respectively. When the sample heated at 600°C was extracted with 0.1 N hydrochloric acid (instead of 3 N) at room temperature (instead of 50°C), the V and r still were 0.202 and 19 - 20, respectively.

When a glass sample is subjected to a double heat treatment, that is heated first at a temperature above 585°C and then at a temperature below 585°C, the following leaching results in glasses having two frequent pore radii. Thus a powder was heated first for 120 hours at 700°C and then for 24 hours at 530°C, and extracted with 0.1 N hydrochloric acid at 18 - 20°C; the pore volume V was 0.249 cu. cm./g., and there were two frequent pore radii near 100 and near 200 angstroms. When a similar powder was heated for 120 hours at 750°C and then for 24 hours at 575°C, the V of the extracted glass was 0.214 cu.cm/g. and the most frequent pore radii were near 40 and above 88 angstroms.

The frequency of relatively large pores (with an r greater than 100 angstroms) is important for the gas permeability of extracted glass. This permeability is 0.14 cu. cm of gas per sq. cm. of glass surface per minute (when the pressure gradient across the glass membrane is one atmosphere per mm.) for "Vycor No. 7930". It varies between 0.15 and 1.2 for glasses of the above composition heated for 3 - 15 days at 530° - 580°C and leached with 0.1 or 3 N hydrochloric acid. However, a double heat treatment (not fully described in the paper) resulted in a porous glass whose V varied between 0.6 and 0.85 cu.cm./g., the most frequent pore radius was near 1000 angstroms, and the gas permeability was 30 to 70.

The authors assume that the relative amount of silica in the borate regions increases with temperature. Above 585°C this amount is so great that silica chains are present in the borate regions also. When the borate is leached out, these chains remain and cause the average pore radius to be small.

Heat resistant tubing of alkali-free glass

V. F. Rudakov and A. F. Kuts report, in *Steklo i Keramika* (*Glass and Ceramics*) *12*, No. 10, p. 27 (1955), on the production of tubing from a new glass, carried out by the Buchan Glass Plant.

The glass composition was SiO_2 61.9 parts; Fe_2O_3 18.5; CaO 15.4; MgO 4.2 and F 4 parts, altogether 104 parts. The batch consisted of 36.5 parts dry sand, 48.5 parts kaolin, 2.2 parts dolomite, 7.5 parts gypsum, and 11 parts fluorspar.

The glass was molten in a tank of 14.5 sq meter area and 900 mm. deep. Because it contained 1.8 per cent Fe_2O_3, the radiant heating of the deeper layers was insufficient; a more shallow tank (for instance 600 mm. deep) would be more suitable. The temperature of the melting end was 1500 ±10°C, of the working end 1290 ±10°C, and of the mandrel chamber 1040 ±10°C. The tilt of the mandrel was 16° - 18°, and the number of its rotations per minute was six.

One of the difficulties encountered consisted in formation of a silica "fur" on the surface of the melt. The thickness of this "fur" was reduced by an increase in the melting temperature to 1560° - 1570°C and by feeding the tank with glass fragments only, but the reduction was not significant.

The amount of glass produced per square meter of tank area was 380 kilograms per day; when the speed was increased to 400 kg., air bells appeared in the cooled glass.

Tubing free from spiral defects was obtained only as long as the linear rate of pull, measured in meters per minute, was greater than the number of rotatations per minute. Thus, when this number was 6, the rate of withdrawal was kept at 7 meters per min. In the instance of the alkali-free glass it was possible to maintain this rate at a level 10 - 15 per cent higher than the rate for the customary alkali glass. The injected air had to be preheated to 100°C.

The alkali-free tubing had good temperature and impact resistance. Ten out of ten samples survived a temperature shock of 100°C when 1-inch tubing, 3 mm thick, was tested; a shock of 95° when the diameter was 1.25 inch and the wall 4.0 mm. thick; and a shock of 90° when these dimensions were 1.50 inch and 4.5 mm. One-meter long tubing of 1 inch diameter cracked under a load of 50.5 kg. when the glass was alkali-free, and at 31.1 kg. when the usual glass was tested. The minimum work of crushing was 0.175 kg. wt.x meter for the alkali-free and 0.150 kg. wt.x meter for the alkali-containing glass.

Effect of treatment on the strength of glass

This was studied by G. M. Bartenev and A. I. Ivanova, *Steklo i Keramika* (*Glass and Ceramics*) *12*, No. 12, p. 7 (1955), on a window glass.

The breaking stress in bending was independent of the degree of annealing as long as the annealing was performed below 600°C. The rupture stress was 745 kg./sq. cm. for a 6 mm. thick, and 885 kg./sq. cm. for a 2.2 mm. thick glass. When the annealing temperature was between 600° and 800°C, the strength increased with temperature, for instance by 10 per cent, because at strong heating fire-polishing started.

When a 6 mm. glass having breaking stress in bending of about 650 kg./sq. cm. was kept in 35 - 40 per cent hydrofluoric acid until a layer 0.05 mm. thick was dissolved away, the strength increased to 1000 kg./sq. cm. The maximum strength of 2700 kg./sq. cm. was reached when the thickness of the removed layer was 0.3 to 0.4 mm. The high strength of the etched glass remained unchanged when the glass was kept for 7 days wrapped in moist paper or heated to 500°C. On the other hand, etched glass, heated to 650°C and rapidly cooled so that its birefringence was 1 - 1.5 N/cm., was as weak as before the treatment with hydrofluoric acid.

Accelerators for glass polishing

The problem of accelerators for glass polishing is discussed in several papers published in *Steklo i Keramika* (*Glass and Ceramics*) *12*, No. 12 (1955). The position seems to be as follows.

High quality polishing rouge is equally efficient when used as a suspension in either pure water or in a solution of zinc sulfate or ferrous sulfate. However, only one out of five rouge samples tested was that good. The thickness or the mass of glass removed by rouge of medium or poor quality is increased by adding zinc sulfate or ferrous sulfate to the suspension; in many instances the poor quality rouge in 1.5 per cent $ZnSO_4$ solution was as efficient as the best rouge in water or a zinc sulfate or ferrous sulfate solution. The improvement achieved by the addition of, for instance, $ZnSO_4$ amounted to 60 per cent for the poorest rouge.

Although zinc sulfate and ferrous sulfate perform about equally as promoters of polishing at room temperature, only zinc sulfate can be used if the temperature of the glass surface rises to 70° because at this and higher temperatures ferrous sulfate is rapidly oxidized to ferric sulfate which is harmful to the polishing process.

It is sometimes observed on large polishing discs that the rouge and the glass fragments form a crust on the felt and that this crust causes deep scratches on the glass surface. Zinc sulfate prevented crust formation to a greater extent than did ferrous sulfate.

The advantages of zinc sulfate were confirmed in production during a three year period.

Comparison of some laboratory glasses

S. K. Dubrovo, S. S. Kayalova and Yu. A. Shmidt present in *Steklo i Keramika* (*Glass and Ceramics*) *12*, No. 10, p. 9 (1955), data on a comparison of several Russian laboratory glasses. The composition of the glasses is not given but their commercial designations are. Glass No. 23 is the glass introduced by V. E. Tishchenko about 60 years ago and used in Russia for about 50 years. The "heat-resistant" glass is almost identical with the "Pyrex" laboratory glass.

The chemical endurance was tested by six methods. In methods 1 to 4, glass goods were kept (for an unspecified time) in boiling water, boiling normal sulfuric acid, boiling 2 N sodium hydroxide or boiling 2 N sodium carbonate; then they were dried, and the loss in weight was determined. This loss in weight (in milligrams) referred to 100 sq. cm. of the surface is shown in Table I. In Method 5, two grams of glass powder with particle sizes between 0.2 and 0.4 mm. were heated for an hour in a quartz flask with distilled water on a water bath, after which the liquid was titrated with 0.01 *N* hydrochloric acid; the number of milliliters of this acid needed for neutralization is recorded in column 5. In Method 6, 4 g. of glass powder were heated with 50 ml. *N* hydrochloric acid for three hours; the number of milligrams of sodium hydroxide found (colorimetrically) in the solution after this treatment is presented in column 6.

Table I.

GLASS	1	2	3	4	5	6
No.. 23	0.3-0.8	0.1-0.4	40-59	8	1.1	0.8-0.9
B-2	-	0.3-0.5	51-60	7	3.4	-
No. 29	0.2-0.7	0.0-0.3	38-59	6	1.0	0.4
L-5	0.5-0.6	0.3-0.5	44-58	6	1.4	1.0-1.2
Ts-32	0.4-1.0	0.4-0.6	27-40	12	2.0	1.8
"Heat resistant"	-	0.3-0.4	89-93	8	0.8	0.6

The softening temperatures and the viscosities of the above glasses are listed in Table II.

Table II

	No. 23	No. 29	L-5	Ts-32	"Heat resistant"
Softening temperature	570	565	550	570-595	615°C
Viscosity, poises, 1400°C	160	185	170	210-250	1450
" " 1000°C	16600	22400	14200	23800	—

Inventions and Inventors

Annealing and Tempering

Apparatus for gauging glassware. Patent No. 2,809,245. Filed April 19, 1955. Issued October 8, 1957. One sheet of drawings; none reproduced. Assigned to Owens-Illinois Glass Company by Pearson T. Menoher, and Kazimier A. Strzala.

The present invention relates to apparatus for gauging glassware, and more particularly, is a device for detecting certain types of imperfections in glass containers, such as bottles, jars and other articles of like general formation. Specifically, the invention pertains to an apparatus for detecting the presence on a ware conveyor of bottles, or such articles of glassware, in which the neck or shoulder portions are tilted or deformed in such manner that the end sealing surface, or rim, defining the mouth of the container lies in a plane other than normal to the major axis of the bottle, or such container, and therefore out of parallelism with the bottom of such container.

The apparatus involved comprises a tilt plate unit in which a tilt plate or disc normally is disposed in a horizontal plane parallel to the wall forming the bottom end of the bottle, jar or such container, but is free to tilt when lowered into contact with the upper end of a bottle or jar in which the top sealing surface is out of parallelism with the bottom wall to an excessive degree. Incident to such tilting of the disc, or tilt plate, a predetermined distance, an electrical circuit is closed and a signal device of conventional or any preferred form will be operated, and the defective article can then be removed manually or automatically in response to closing of such circuit. Provision is made for adjusting the spacing of the electrical contacts to the end that the apparatus may be set so as to detect only those articles which are outside of the specifications that have been established for any particular article of glassware. It is obvious that if the abnormal positioning of the neck or finish is within certain limits the article is commercially usable.

There were 4 claims and the following references cited in this patent: 1,084,155, Lochman, Jan. 13, 1914; 1,716,373, Ellis, June 11, 1929; 1,772,540, Fowler, Aug. 12, 1930; 2,575,227, Morcom, Nov. 13, 1951.

Glass to metal seal for high-frequency electronic tubes. Patent No. 2,808,448. Filed February 26, 1951. Issued October 1, 1957. One sheet of drawings; none reproduced. Assigned to Compagnie Generale de Telegraphie Sans Fil by Jacques Bleuze and Pierre Dussaussoy.

The invention refers to lead-through arrangements for connecting external electrical conductors to apparatus mounted in air tight enclosures, and more particularly, it relates to lead-through arrangements for tubes operating at very high frequencies; for instance, in the centimeter wave length range. It is particularly applicable to lead-through arrangements of a conductor in Kovar or similar metals passing through glass or any other insulating substance, and sealed to the latter so as to be air tight.

A thin coat or film of silver, or any other equivalent metal not easily oxidizable or completely unoxidizable, is introduced into the joint, between the glass envelope and the Kovar conductor. This coat is disposed with respect to the Kovar and joined to it, so as to constitute for the current circulating on the metal surface a path of high electric conductibility through the air-tight zone of the joint.

It has been ascertained that when this film is directly laid on the metallic conductor, the contact between silver and Kovar is not always perfect and stable and, after a long while, will often fail to keep tight under high vacuum conditions. To obviate this inconvenience, according to the principal characteristic of the invention, a coat of glass, or similar substance, adhering to the conductor in intimate and air-tight manner is introduced between the silver film and the conductor, the dilatation coefficient of this coat being adjusted to the coefficients of the conductor and the envelope.

According to a preferred embodiment of the present invention, in order not to deform the trajectories of the current on the surface, and to avoid any discontinuity, this glass coat is inserted into a hollow or groove made in the conductor, the silver film being flush with the surface of the conductor and forming its natural prolongation. This coat of glass will extend along a great part of the length of the joint, and in most of the cases will occupy the whole zone of the joint and will even extend beyond it. It will bear the said silver film in the zone of the joint.

There were 6 claims and the following references cited in this patent: 1,118,905, Mailey, Nov. 24, 1914; 2,014,809, Kuhle et al., Sept. 17, 1935; 2,100,187, Handrek, Nov. 23, 1937; 2,169,570, Ronci, Aug. 15, 1939; 2,202,500, Lopp, May 28, 1940; 2,240,064, Allen et al., Apr. 29, 1941; 2,446,277, Gordon, Aug. 3, 1948; 2,456,653, Snow et al., Dec. 21, 1948; 2,520,663, Tromp, Aug. 29. 1950.

Feeding and Forming

Method of Shaping A Glass Article. Patent No. 2,795,084. Filed July 20, 1955. Issued June 11, 1957. One sheet of drawings; none reproduced. Assigned to Corning Glass Works, by Jesse T. Littleton.

This invention relates to improvements in the art of reshaping the surface of a glass body to conform with the contour of a surface of a mold, or of a second glass body, by contacting said surfaces with or without the application of external pressure while heated.

In accordance with the invention the method in its broader aspect comprises conforming a surface of a glass body with the contour of a surface of another body, such as a metal mold or another glass body, by forming on the contacting glass surface, or surfaces, an adherent

metal oxide film and placing the bodies together, shaping the glass surface, or surfaces, while the bodies are heated sufficiently to permit plastic flow and conformation of the glass.

For conforming a plurality of glass bodies under the application of external pressure, the method comprises forming on the contacting surfaces of the glass bodies a substantially transparent iridized metal oxide film, placing said surfaces together and applying pressure to urge said surfaces into intimate contact while heating said bodies between the strain point and the softening point of the softer glass until said surfaces are conformed to each other and the stresses induced by such pressure have been released, then cooling said bodies and removing the pressure. (Strain point is the temperature at which the viscosity of the glass is $10^{14.5}$ poises.)

There were 13 claims and the following reference cited in this patent: 2,118,795, Littleton, May 24, 1938.

Furnaces

Glass Bending Apparatus. Patent No. 2,798,338. Filed March 10, 1953. Issued July 9, 1957. Two sheets of drawings; none reproduced. Assigned to Libbey-Owens-Ford Glass Company by Joseph E. Jendrisak.

This patent relates broadly to apparatus for bending glass sheets or plates. More particularly, it relates to an improved means for locating and retaining glass sheets in proper relation to a mold during the bending operation.

It is frequently necessary, in the bending of flat glass sheets to irregular shapes, to cause the end portions of the sheet to undergo a significant change with respect to the side portions.

According to this invention, there is provided at each end of the bending mold a sheet edge locating and retaining means which is mounted adjacent to the shaping surface of the mold. It is universally movable with respect thereto in order to retain said edge in proper bending relation to said shaping surface at all times during the actual bending operation, by adapting its movement to that of said edge.

There were seven claims and the following references cited in this patent: 2,518,951, Smith, Aug. 15, 1950; 2,554,572, Jendrisak, May 29, 1951, 2,608,799, Babcock, Sept. 2, 1952.

Glass Compositions

Glass. Patent No. 2,799,590. Filed May 21, 1954. Issued July 16, 1957. No drawings. Assigned to Corning Glass Works by William H. Armistead.

This invention relates to glass compositions and has for its primary object a composition having viscosity characteristics such that it can be drawn in a continuous sheet 0.13-0.16 mm. thick by the downdraw process by automatic apparatus.

To obtain a sufficiently high viscosity to enable prior glasses, otherwise suitable for the present purpose, to be drawn in the desired thinness, it was found that the temperature of the molten glass must be lowered to such a degree that it is near, or below, the liquidus of the glass, the highest temperature at which crystals of any kind can form or separate from the molten glass in equilibrium with the glass.

It has been discovered that the introduction of 2-8 per cent of TiO_2 into the composition of glasses, which otherwise have too high liquidus or too low chemical durability, results in a favorable change of both the liquidus and the durability rendering them suitable for the present purpose.

The following examples, calculated in weight per cent on the oxide basis from their batches, illustrate glass compositions falling within the scope of this invention:

	1	2	3	4	5	6
SiO_2	62	64	67	62	65	65
TiO_2	5	5	3	8	5	4
Na_2O	7	7	9	3	6	7
K_2O	7.8	7	4	12	6	7
B_2O_3	9.2	8	4	10	5	4
ZnO	7	7	4	5	5	12
MgO	—	—	4	—	—	—
PbO	—	—	—	—	5	—
Al_2O_3	2	2	5	—	3	1

To draw glasses of the present type by means of the apparatus described in the above-mentioned patent in a thickness of 0.13-0.16 mm. from an orifice having a thickness of 3/8 inch, a viscosity of 30,000 - 40,000 poises and a linear drawing speed of 200 feet per minute is required. The temperature of the glass at the orifice is 935°-955° C. The liquidus of each of the compositions described above is below 935° C. and the chemical durability of each glass is ample for the present purpose.

On the contrary, with proportions falling outside of the above-recited range the glass will either have a liquidus above 950° C. or have an undesirably low chemical durability rendering it unsuitable for microscope cover glasses and the like.

There were four claims and the following reference cited in this patent: Re. 23,049, Armistead, Nov. 23, 1948.

Media for Dispersing Glass Fibers. Patent No. 2,802,734. Filed December 23, 1954. Issued August 13, 1957. No drawings. Assigned to American Machine & Foundry Company by David Bandel and William K. W. Chen.

This invention relates to the preparation of a fluid dispersion of glass fibers suitable for paper making. Particularly, the invention relates to the dispersion of glass fibers in an aqueous polyacid medium.

Excellent fiber dispersions of high uniformity and stability can be prepared at higher pH values (about 2.5 to 4.5) than is possible with strong mineral acids if a polyacid, inorganic or organic, is used to acidify the medum in which the fiber is beaten. This discovery eliminates many disadvantages inherent in the use of strong corrosive mineral acids at low pH values. In particular, phosphoric acid is highly suited as a weak inorganic polyacid and citric acid as a weak organic polyacid. Another polyacid that can be used is carboxymethyl cellulose free acid, also know as cellulose glycolic acid.

In a preferred example of the invention 1½ grams of three-quarter micron glass fiber was added to half a liter of water in which 0.15 gram of citric acid was dissolved. The mixture was beaten for fifteen minutes in a "Waring Blendor" and produced a good dispersion which made satisfactory paper. The pH before beating was 3.14 and after beating, as a result of acid reactions with sodium oxide leached from the glass, had risen to 4.25.

(*Continued on page* 400)

Research Digest

Inhibition of Alkaline Attack on Soda-Lime Glass

• COMMON ALKALINE SOLUTIONS have a disruptive effect upon the glass structure. The action is much more severe than that of most neutral or acidic solutions. Prolonged action etches or dulls the surface. Some of the products of disintegrated glass are often present as a soft, hydrous, gel-like siliceous film on the surface.

The adhesion of this film varies. In the case of an alkaline solution, such as household ammonia held in a bottle, detached flakes of such a film may appear suspended in the solution. Constitutionally, soda-lime glass is poorly suited to withstand the action of alkaline solutions.

However, means of inhibiting alkaline attack on glass were reported by Geffcken, who noted that the presence of small amounts of potassium silicate, or the hydroxides of the multivalent metals, greatly reduced the rate of caustic attack under certain conditions. The monovalent metal ions and boric acid were found to be ineffective.

Since Geffcken reported his findings, a number of patents have appeared outlining the inhibiting effect of certain agents upon alkaline attack. Most of the activity has been carried on in regard to substances that might be added to the solutions used in washing and sterilizing returnable beverage bottles. The washing solutions usually contain 3 to 6 percent sodium hydroxide, and the bottles are subjected to such solutions at elevated temperatures for periods lasting from five to 15 minutes. At the temperatures and concentrations employed, the outside surface of the bottles is noticeably affected, and is more easily scuffed by contact with the metallic parts of the washer or by the rubbing of glass on glass.

Cooper found that relatively small amounts of aluminate greatly reduced the action of caustic washing solutions. Later, a group of investigators working at the Wyandotte Chemical Corp. in Michigan filed a number of patents noting the value of certain agents in reducing the alkaline attack upon glass.

They found that compounds of zinc and beryllium are very effective in reducing alkaline attack. The inhibiting ability of beryllium is especially noteworthy. Its presence in small concentration reduces the attack of strong alkaline solutions upon glass to an amount comparable with the attack of water.

The Wyandotte group also patented the use of a number of organic inhibitors. These are compounds belonging to a family possessing at least three hydroxy groups attached to adjacent benzenoid carbon atoms. The simplest member of this family is pyrogallol. Monohydroxy- and dihydroxy-benzene derivatives were found to be ineffective.

Another patent noted a number of less effective inhibiting agents, including compounds of stannic and stannous tin, barium, strontium, bismuth, and antimony.

According to Weyl, an agent which is to inhibit alkaline attack must be adsorbed on the surface of the glass and must not form easily soluble compounds under conditions existing at the glass surface. The inhibitors of attack are, for the most part, inorganic cations with a valence of two or more.

Weyl has related the effectiveness of a cation in reducing alkaline attack to its field strength. This field strength may be approximated by dividing the valency of the cation by the square of its ionic radius. It was noted that the evaluation of the inhibiting ability of a cation in terms of field strength has limitations, because of the possibility of a variation of the ionic radius due to polarization, and because of the inherent differences between ions with complete and incomplete outer electron shells. It has also been noted that the effectiveness of a cation as an inhibitor may be impaired at certain alkaline concentrations, since the cation may surround itself with oxygen atoms, forming an anionic complex, which, according to Weyl, would be repelled from the surface of the glass. Aluminum, for example, forms AlO_2^- ions in strongly alkaline solutions.

The presence of phosphates and certain concentrations of silicates has been found to accelerate the rate of alkaline attack upon glass. Weyl suggested that this increase in attack was caused by the complexing of the aluminum ions freed by the caustic attack. The aluminum ions normally would be adsorbed by the glass and exert an inhibiting action, but at certain concentrations of silicic acid, an alumino-silicate complex forms, destroying the inhibiting value of the aluminum cations. The apparent acceleration of alkaline attack upon glass due to the presence of phosphates has been explained by the ability of the phosphates to form anionic complexes with a weak inhibitor such as calcium.

As little information is given in the literature concerning the compositions of the glasses tested, and the available data do not permit a comparison of the effectiveness of equal concentrations of the different inhibiting or modifying agents, Hudson and Bacon[1] report the results of a study in which the inhibiting ability of a group of these agents was compared on an equal atom concentration basis.

Concentrations of two and ten milligram-atoms of each modifier per kilogram of 3 per cent sodium hydroxide were chosen. Bottles of two different glass compositions (one a calcite glass and the other, a dolomite glass) were used as the subjects of attack. The results obtained were expressed as loss in weight of the bottles after 28 days at 125°F.

The order of agents from the most to the least effective in reducing the attack of a solution of 3 per cent sodium hydroxide on soda-lime glasses was found to be: beryllium, pyrogallol, zinc, strontium, antimony (trivalent), barium, aluminum, and lead. Bismuth, copper, magne-

[1]American Ceramic Society Bulletin, April, 1958

sium, and zirconium are precipitated by the caustic and are ineffective as inhibitors. *Stannous* tin is not precipitated, but has little inhibiting effect. *Stannic* tin was found to increase the rate of attack. Silicon was found to both increase and decrease the attack, depending upon its concentration.

PIM PROMOTED BY LOF GLASS FIBERS

Richard A. Pim, formerly process development manager of L.O.F. Glass Fibers Company, has been appointed chief engineer of the eastern division. He has complete supervision of engineering operations in all eastern division plants and will maintain his headquarters at the company's technical center in Waterville.

He has been close to the glass industry for 22 years, having started as a project engineer for the old Libbey Glass Company, then chief tool designer for Maumee Engineering Company, and a project engineer for Owens-Illinois Glass Company. In 1949 he joined Glass Fibers Inc. as process development manager and continued in that capacity following the merger of that organization with the Fiber Glass and Corrulux Divisions of Libbey-Owens-Ford Glass Company in 1955 to form L.O.F. Glass Fibers.

Richard A. Pim

BLUE RIDGE A DIV. OF SAINT GOBAIN

Blue Ridge Glass Corporation, which recently merged with American Window Glass Company is now being operated under the name Blue Ridge Glass, a Division of American-Saint Gobain Corporation, following acquisition by Saint Gobain.

NEW MOLD SHOP FOR KNOX GLASS

Knox Glass Incorporated formally opened its new mold shop at Reno, Penna., during the latter part of May. The plant will produce molds for all types of glass containers manufactured for Knox customers who are served from the Gas City, Indiana, plant, and from the three Pennsylvania plants at Knox, Marienville and Parker. Later this summer, the shop will start producing molds for use at Danielson, Conn., where the company is currently completing the installation of an entirely new manufacturing facility to serve the New England market its new manufacturing facility, which will be the first glass container plant in New England.

Ben T. Huggler, formerly plant manager of Knox Glass Incorporated at Marienville, Penna., has been transferred to Danielson. Succeeding Mr. Huggler at Marienville is Earl G. Tempest, who had previously been superintendent of that plant.

These assignments are the forerunner of wide numbers of personnel shifts and promotions made necessary by contemplated transfers of key executive personnel to the Danielson operation, according to Howard B. Steele, manager of manufacturing.

GLASS TUBING FOR CORES IN CASTING

Corhart Refractories Company has developed a method of precision-forming tiny cores in high-temperature metal casting by fixing glass tubing to the inside of a precision casting mold before pouring. The tiny sections of 96 per cent silica glass tubing, whose outside diameters are as small as 0.020 inch, can withstand casting temperatures of more than 3000°F.

After the metal has cooled, the glass tubing can be leached by molten caustic without harming the casting, leaving a core of precise measurements which requires no machining.

ANTIQUE PHARMACEUTICAL BOTTLE

Armstrong Cork Company has presented an antique pharmaceutical bottle, the only one of its kind so far discovered, to Parke, Davis & Co. for its museum in Detroit. A medium wide-mouth French square, the bottle was hand made before the beginning of this century by Whitall-Tatum & Company at its Millville, N. J., plant. This company was later purchased by Armstrong Cork.

A picture of the bottle appears in an 1898 Parke, Davis catalog.

PENNA. GLASS SAND SCHOLARSHIP

Continuing its scholarship program this year, the Pennsylvania Glass Sand Corporation will award a scholarship to the outstanding junior ceramic engineering student at each of 12 colleges and universities. Each recipient will be granted full tuition for his senior year in ceramic engineering.

William J. Woods, Jr., vice-president, stated that opportunities available to young, qualified ceramic engineers are practically unlimited; yet there are not enough ceramic engineers graduated each year to meet industry requirements.

Those schools participating in the Pennsylvania Glass Sand Scholarship Program this year are Alfred University, Clemson Agricultural College, Georgia Institute of Technology, Iowa State College, Ohio State University, Pennsylvania State University, Rutgers University, University of Illinois, University of Missouri, University of Texas, University of Washington and Virginia Polytechnic Institute.

HIGH TEMPERATURE WINDSHIELDS

Under a $2,380,000 contract recently awarded Corning Glass Works by the U. S. Air Force, the company will develop high-temperature windshields for supersonic aircraft.

Both flat and curved windshield sections will be fabricated and will be capable of withstanding continuous use at temperatures of 850° to 900°F. The windshields will be coated with an electrically conducting film to act as a de-icing and de-fogging agent as well as to reflect solar infrared radiation.

Because of the high-temperature requirements, the program will involve new techniques for shaping, laminating and mounting the windshields. The operating temperature range called for in the new contract is about double the limit of glasses used in present standard windshields.

Current Statistical Position of Glass

Employment and payrolls: Employment in the glass industry during April, 1958, was as follows: *Flat Glass*: A preliminary figure of 21,600 given for April, 1958, indicates a decrease of 4.0 per cent from the adjusted 22,500 reported for March, 1958. *Glass and Glassware, Pressed and Blown*: A decrease of 1.1 per cent is shown by the preliminary figure of 74,700 reported for April, 1958, when compared with the adjusted figure of 75,500 recorded for March, 1958. *Glass Products Made of Purchased Glass*: The preliminary figure of 11,100 given for April, 1958, indicates a decrease of 1.7 per cent from the previous month's adjusted figure of 11,300.

Payrolls in the glass industry during April, 1958, were as follows: *Flat Glass*: a decrease of 8.02 per cent is shown in the preliminary $9,685,918.87 given for April, 1958, when compared with March's adjusted $10,531,139.85. *Glass and Glassware, Pressed and Blown*: A decrease of 3.1 per cent is shown in the preliminary $27,337,598.95 reported for April, 1958, when compared with the previous month's adjusted $28,206,140.13. *Glass Products Made of Purchased Glass*: A preliminary figure of $3,238,323.88 was reported for April, 1958. This is a decrease of 3.1 per cent when compared with the adjusted figure of $3,339,269.78 recorded for March, 1958.

Glass container production: Production based on figures released by the Bureau of the Census, Industry Division, was 12,201,000 gross during May, 1958. This is an increase of 9.3 per cent over the previous month's production figure, 11,158,000 gross. During May, 1957, glass container production was 12,557,000 gross, or 2.9 per cent above the May, 1958, figure. At the end of the first five months of 1958, glass container manufacturers have produced a preliminary total of 58,188,000 gross. This is 3.1 per cent below the 60,081,000 gross produced during the same period in 1957.

Shipments of glass containers during May, 1958, came to 12,508,000 gross, an increase of 12.3 per cent over April, 1958, shipments which totaled 11,135,000 gross. Shipments during May, 1957 amounted to 12,907,000 gross, or 3.2 per cent above May, 1958. At the end of the first five months of 1958, shipments have reached a preliminary total of 56,551,000 gross, which is 1.1 per cent over the 55,918,000 gross shipped during the same period of the previous year.

Stocks on hand at the end of May, 1958, came to 18,825,000 gross. This is 1.1 per cent below the 19,027,000 gross on hand at the end of April, 1958, and 6.6 per cent higher than the 17,653,000 gross on hand at the end of May, 1957.

GLASS CONTAINER SHIPMENTS

(All Figures in Gross)

Narrow Neck Containers

	May, 1958
Food	1,157,000
Medicinal and Health Supplies	1,313,000
Chemical, Household and Industrial	853,000
Toiletries and Cosmetics	836,000
Beverage, Returnable	828,000
Beverage, Non-Returnable	138,000
Beer, Returnable	667,000
Beer, Non-Returnable	831,000
Liquor	815,000
Wine	340,000
Sub-total (Narrow)	7,778,000

Wide Mouth Containers

Food	*3,469,000
Medicinal and Health Supplies	385,000
Chemical, Household and Industrial	186,000
Toiletries and Cosmetics	278,000
Packers' Tumblers	42,000
Dairy Products	137,000
Sub-total (Wide)	4,497,000
Total Domestic	12,275,000
Export Shipments	233,000
TOTAL SHIPMENTS	*12,508,000

*This figure includes Fruit Jars and Jelly Glasses.

GLASS CONTAINER PRODUCTION AND INVENTORY

(All Figures in Gross)

		Production May, 1958	Stocks May, 1958
Food, Medicinal and Health Supplies; Chemical, Household and Industrial; Toiletries and Cosmetics	Narrow Neck	4,272,000	6,966,000
	Wide Mouth	*4,192,000	*6,064,000
Beverage, Returnable		905,000	2,020,000
Beverage, Non-Returnable		168,000	241,000
Beer, Returnable		605,000	423,000
Beer, Non-Returnable		741,000	758,000
Liquor		754,000	1,246,000
Wine		355,000	646,000
Packers' Tumblers		63,000	124,000
Dairy Products		146,000	337,000
TOTAL		*12,201,000	*18,825,000

*This figure includes Fruit Jars and Jelly Glasses.

NEW PLANT FOR LABORATORY GLASSWARE

Corning Glass Works last month opened a new plant, in Big Flats, N. Y., which is devoted entirely to the fabrication of laboratory glassware.

The plant makes over 10,000 different products, ranging from simple test tubes to the highly complicated extraction ware for the laboratory field. This includes about 1500 stock laboratory glassware items and up to 8500 different types of custom-made apparatus produced on order.

J. L. HANIGAN BECOMES PRESIDENT

John L. Hanigan was recently elected president of Corning Glass Works of Canada Ltd.

Mr. Hanigan is a vice president of Corning Glass Works, parent company of the Canadian wholly owned subsidiary, and general manager of the former's Electrical Products Division.

New Equipment and Supplies

NEW HIGH-TEMP. FURNACE

The Zirconium Corporation of America is offering a laboratory-size furnace for use at temperatures up to 4600°F in oxidizing atmospheres. It has a skin temperature of less than 200°F when operating at 4600°F and can be used in almost any laboratory surroundings. The furnace is 21 inches high, 18 inches in diameter, and has a firing chamber 6 inches in diameter and 6-8 inches deep.

For achieving maximum temperatures, oxygen-acetylene fuel is used.

CERAMIC-INSULATED THERMOCOUPLE WIRE

E. C. Smith Manufacturing Co., Conshohocken, Penna., is making a new metal-sheathed, ceramic-insulated thermocouple wire that combines high electrical sensitivity with small size and flexibility. The thermocouple wire, called CeramiKouple, is designed to withstand high temperatures and corrosive atmospheres encountered in heavy-duty industrial and research applications.

It bends on a radius as small as its own diameter without collapsing the metal sheath or shorting the wires. This flexibility plus small size permits it to reach previously inaccessible "hot spots."

Because of its small thermal mass, CeramiKouple has a high sensitivity. It provides the quick thermal response necessary to the operation of complex control systems which cannot tolerate slow signals.

The thermocouple wire is a good electrical insulator to 3000°F. Ceramic insulation materials used are magnesium oxide or aluminum oxide. Both have melting points well above application temperatures.

TEMPERATURE MEASUREMENT

Shaw Instrument Corporation, 49 Verona Road, Pittsburgh 21, Penna., has developed an instrument which will measure the temperature of any solid, liquid or luminous flame in the 1500°F to 4000°F range without first having to make emissivity corrections. Called the Shawmeter, the instrument will measure temperatures of moving objects in a furnace rather than the furnace temperature itself.

This instrument employs a radical approach to temperature measurement which eliminates human factors, provides accuracy to within 20°F and permits use of automatic controls previously considered impossible, according to the manufacturer. Readings may be translated automatically to control processing in steel melting, ceramic, glass, annealing and heat-treating and similar applications.

The Shawmeter, a radiation ratio pyrometer, consists of two units, a sensing head for detecting radiation, and a control unit which interprets the information. Temperature is indicated on a seven inch meter calibrated directly in degrees. A 0-100 millivolt output is provided for operating a strip chart recorder or controller. Automatic in operation and free from deteriorating components, it has a speed of response of a fraction of a second.

Temperatures of items smaller than a lamp filament or as large as the sun can be measured. The instrument also permits investigation of small temperature changes in large or small objects.

CIRCULAR CHART RECORDER

Hays Corporation, Michigan City, Indiana, has developed a new circular chart recorder, with which a maximum of four records can be included on one chart. Inputs such as flow, gas analysis, pH and pressure can be handled on a single equally divided chart.

AUTOMATIC SEALING MACHINE

Kahle Engineering Co., North Bergen, N. J., has developed a new 8-position, 8-head automatic sealing machine which permits the mass production of glass inner terminal units for electron tubes. In addition to completing the glassing sequence—including pre-heating, glass melting, joining with metal, spacing, glass forming and cooling—the new machine positions a pin which formerly required a special operation.

GLASS STRIPPING MACHINE

Biddle Engineering Co., Warrendale, Penna., has an improved production glass stripping machine with fewer moving parts. A single screw controls the size adjustment of the head and also permits the addition or removal of a complete cutter assembly.

DUST COLLECTORS

The Kirk & Blum Manufacturing Company, Cincinnati, Ohio, is making new type "M" Unit Dust Collectors, in all sizes of which the dust-laden air is delivered to a small-diameter precleaner where all but the finest particles are removed. The air then passes through steel wool filter pads, three inches thick, for final cleaning.

ANNEALS GLASS TO METAL

Raytheon Manufacturing Company has developed an automatic machine which it uses in its magnetron tube production for annealing glass-to-metal sealed sub-assemblies. The machine completes this operation in minutes instead of hours and employs a rotary conveyor with eight radial fixtures in the form of tapered rods.

Every 14 seconds the eight fixtures are indexed 45°, bringing them successively in line with 5 groups of gas jets which are precisely adjusted so that the initial temperature of 400°C gradually falls to 100°C during the two-minute cycle.

CATALOGS RECEIVED

The Conveyor Equipment Manufacturers Association recently published "Conveyor Terms and Definitions, Book No. 101," an enlarged edition of an earlier book. The 96-page volume defines more than 1200 conveyor types, parts and related equipment. "Preferred" terms are accompanied by the definitions, and other commonly used terms are related to them by an extensive system of cross indexing. This book is available from the Association at One Thomas Circle, Washington 5, D. C. and costs $2.

Bailey Meter Company, 1050 Ivanhoe Road, Cleveland 10, Ohio, has issued a 16-page catalogue containing details of the plug-in components for the Bailey Recorder. There are descriptions of 12 types of receivers, controllers, retransmitters, and direct measuring devices from which the recorder may be custom-built.

Little Giant Products, Inc., Peoria, Ill., is distributing a catalog of mechanical and hydraulic Lift Truck Attachments illustrating 26 ways in which operators can derive more use from their lift trucks.

Automatic Switch Company, Florham Park, N. J., has published a new booklet on applications of automatic transfer switches, and how to select them. Entitled, "Factors to Consider in the Selection and Application of Automatic Transfer Switches," Publication 596R1 discusses such requirements as in rush capacity, continuous duty rating, rapid transferral of load, high thermal capacity and ability to withstand electromagnetic effects, double source control, full phase protection, and various structural and operational features.

Columbia-Southern, a dependable supplier of soda ash to the glass industry since 1899, manufactures its soda ash with extreme care to conform with the characteristics of other raw materials for superior glassmaking

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INTERNATIONAL COMPARISON OF HIGH-TEMPERATURE STANDARDS

Precise international comparisons have established that the optical pyrometer temperature scales of Canada, the United Kingdom, Germany, and the United States are in satisfactory agreement. Thus, within these countries, all measurements of high temperatures now have a common basis, and the results obtained in one laboratory should be comparable with those of another.

Above 1063°C (the freezing point of gold) optical pyrometers are the standard instruments used to measure the brightness temperatures of incandescent bodies. This measurement consists of visual comparison of a portion of the radiation from the hot body with that emanating from an incandescent lamp filament contained in the pyrometer. The standard optical pyrometer is calibrated by determining the pyrometer lamp current which corresponds to a stated brightness temperature. This is done at 1063°C by comparing its brightness with that from a hollow body (black body) surrounded by freezing gold. Higher temperatures are calculated from Planck's radiation equation utilizing measured brightness ratios.

Because the specially constructed optical pyrometers used as standards are not readily portable, it is not practical to send them abroad for international intercomparisons. However, it has been found that tungsten strip lamps, when used under rigidly controlled conditions, afford a means of reproducing brightness temperatures up to 2300°C with a precision comparable to that attained with standard pyrometers.

In November, 1955, both the National Bureau of Standards and the Physikalisch-Technische Bundesanstalt, the national standards laboratory of Germany, completed the calibration of two tungsten strip lamps, each laboratory comparing the lamps against its standard optical pyrometer. The results revealed a systematic difference, varying from 7 deg at 1100°C to 20 deg at 2300°C, between corresponding values obtained at the two laboratories. Inasmuch as the National Bureau of Standards normally certifies the calibration of tungsten strip lamps to 3 deg at 1100°C and to 7 deg at 2300°C, the discrepancy between the German and the American values caused some concern.

In 1956 a new primary calibration of the Bureau's standard pyrometer was performed, and the techniques used in the primary calibration and in the calibration of strip lamps were carefully investigated. Some minor changes in the lamp calibration values resulted, but these effects were very small compared to the discrepancy.

Arrangements were then made for an intercomparison of a group of calibrated tungsten strip lamps between the National Research Council of Canada and the National Bureau of Standards. Two of the Canadian lamps included in the exchange had previously received a routine calibration at the National Physical Laboratory in England in addition to the Canadian calibration. These intercomparisons, among the three national laboratories completed in April, 1957, had a standard deviation of only 1.2 deg. C for 90 points in the range from 800° to 2200°C.

When these results were reported to the Physikalisch-Technische Bundesanstalt, the discrepancy was finally resolved. It was found that a new ceramic hollow body used as a black body in the German laboratory's primary pyrometer calibration had not completely fulfilled black-body conditions. This was recognized by the German Laboratory shortly after the German intercomparison but the National Bureau of Standards did not receive this information until further tests had been completed. The resulting error in the pyrometer calibration had caused the apparent systematic error in the German-American intercomparison of tungsten strip lamps. Correction of this error has now brought about satisfactory agreement between the optical pyrometer portions of the International Temperature Scale as maintained in the 4 countries.

FEHRLE JOINS BAUSCH & LOMB

Dr. Kurt Fehrle, a graduate of the Technical University of Stuttgart, specializing in electrical research, has joined the Glass Engineering department of Bausch & Lomb's Chemical Research Laboratories.

BASIC REFRACTORIES RESEARCH

Dr. Leonard Reed, M. L. Van Dreser and J. R. Bachman have been appointed as specialists in basic refractories research and development activities at the Milpitas, Calif., laboratory of Kaiser Aluminum & Chemical Corp.

Mr. Van Dreser heads development work on new basic refractory products for use in the glass industry.

Eighth Overmyer Iron Clinic

(*Continued from page* 381)

base metal. Because chromium is diffused and not deposited on the surface, it becomes an integral part of the base metal. There is no "build up" as in plated parts.

The Chromalloy process has unlimited throwing power, and the chromium is diffused uniformally into recesses, corners, scratches and finish irregularities which are present in minute form. The finish is pore free, continuous and highly uniform in depth, structure and composition. A lustrous finish may therefore be obtained with relative ease. The advantages found thus far are extremely desirable from the standpoint of glass mold operation requirements. They are:

1. Prevents scaling and corrosion at high temperatures.
2. Resists galling, crazing and other types of surface deterioration.
3. Produces minimum dimensional change.
4. Provides greater wear life and longer continuous production runs.
5. Strengthens the bond of powdered spray metal.
6. Produces a ductile, easy-to-work surface.

Mr. Flatter then introduced Mr. Daniel Lehane, Manager of Sales Engineering for the Chromalloy Corporation who discussed the origin of the process in England and the applications made by the glass industry in that country.

Research and Development

Mr. Flatter continued the program with his comments on the newly established Overmyer Research and Development program at the Winchester Plant.

"The primary purpose of this newly created department," he said, "is to search out new and better production methods, and, when properly developed, this department will be responsible for installation of these

improvements in all Overmyer plants. All research activities are to be coordinated through this department to lessen duplicated effort. The immediate results to our customers are a better product and, where practical, a lower cost.

"In addition to internal research, we are constantly looking for better ideas, methods and processes for the glass industry. This leads us to the next subject, which I am sure you will find of interest."

T-3 Alloy

Mr. Flatter introduced Norman A. Birch of the National Bearing Division of American Brake Shoe Company for his discussion of T-3 Alloy metal for glass mold application. Mr. Birch explained that T-3 is a copper base alloy which has been combined with nickel, aluminum and zinc. He added that refinements in alloy composition and foundry techniques have more recently made T-3 of commercial interest. In contrast to bronze alloys, the T-3 metal provides more uniform expansion characteristics and is more readily available than other types have been in the past.

Applications of T-3 metal within the glass industry have created a large use in the most highly stressed or critical parts of glass molds—that is, in neck rings, plungers, bottom plates, certain press molds, baffles and in the production of borosilicate glass items.

One of the principal advantages of T-3 alloy is that it requires considerably less lubrication (swabbing) and permits longer, trouble-free operation without cleaning. There are even reports that it has been run completely dry with consequent savings in glass. The largest use of T-3 type alloy is in neck rings (used as the standard metal by several large producers). Its use is rapidly being extended to wherever trouble develops as glass machines are pushed to higher and higher production rates.

Viewing 1-F Fastermatic ring finish operation.

Mr. Birch concluded his remarks by discussing machining and welding practices.

The technical portion of the meeting was concluded by Mr. Flatter who said that personnel would be available in the afternoon for those who wished to cover the morning's subjects in greater detail.

The Eighth Iron Clinic was concluded with a Banquet in the evening, with Max Hawkins, Omco Sales Manager, acting as host.

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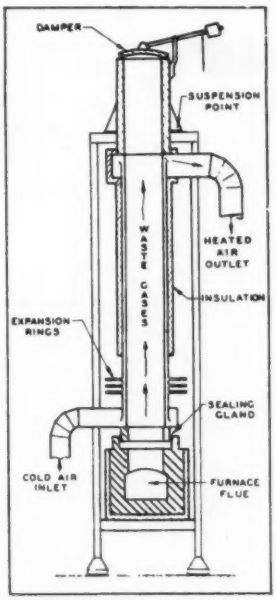

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Side Port Furnaces

(*Continued from page* 377)

Figure 4 indicates the fuel distribution down the length of the furnace to obtain the represented temperature curve for the normal load. Once these conditions are set for the particular furnace, the designer can apply the calculated fuel requirements to size and position the furnace ports to obtain the lengthwise distribution desired.

Many practical considerations guide the designer in this respect, some of these being, the physical limitations of construction to provide adequate operational and maintenance clearances, the height of the furnace spring line, the type of fuel utilized and the width of the furnace in relation to its length.

The uniform release of heat across the hearth is a different matter. Characteristics of the fuel used and the flame quality play an important part in its application.

In obtaining uniform heat distribution to the glass across the width of the melter, the flame must also retain the desirable glass melting characteristics.

Radiant quality, temperature and temperature distribution along the length of the flame play an important role in the fuel application. These qualities change with the type of fuel and the method of firing.

Figure 5 shows the distribution of temperature for various type flames. The temperature gradient along the length of a flame is dependent upon many variables and the point of maximum temperature can be adjusted. However, such changes will undoubtedly change the emissivity of the flame.

In order to obtain the desired flame characteristics for the particular application, the following adjustments

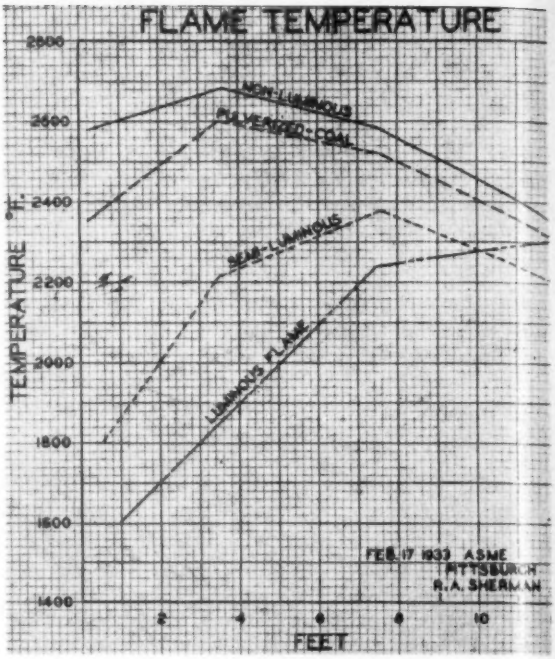
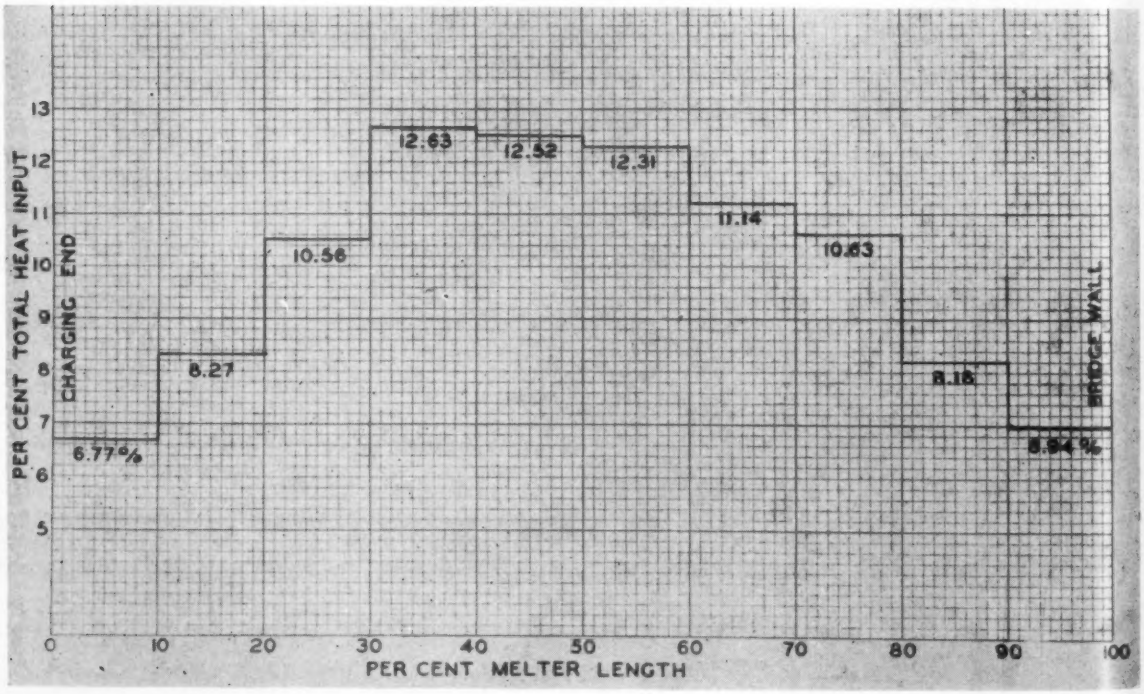


Fig. 5

can be made to certain variables:

1. An increase in combustion air preheat temperature results in an increase to the temperature of the flame. (i. e. Section II an increase of 100° F in combustion air results in an increase of 48° F flame temperature.) (*Continued on page* 398)

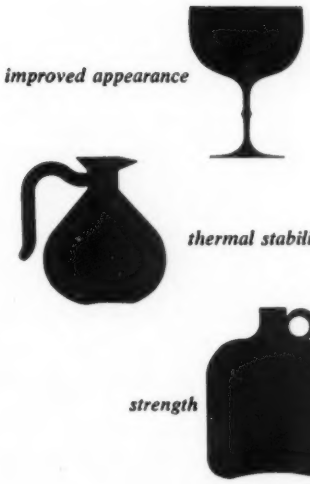
Fig. 4. Heat Input Curve.



BORON: B

a vital constituent for glass

because B_2O_3 betters the batch



Boron is much in the news today. New, and sometimes startling, uses for boron are being found in rapid succession. But the virtues and functions of boron trioxide are well known to the makers of glass. They've been the major users of borax since ancient days. First, to make incomparable glazes; later, to impart to glass a desirable resistance to thermal and mechanical shock. Down through the ages into present-day usage, the four valuable properties of B_2O_3 have benefited the glass industry by—(1) improved fluxing of the batch, (2) decreased coefficient of expansion, (3) increased resistance to corrosion, (4) influence on the refractive index.

From our lengthy list, the greatest diversity of borates and boron products in the world, we offer the following group as satisfactory sources for B_2O_3 for the manufacture of all types of glass:

- **ANHYDROUS BORAX,** $Na_2B_4O_7$
- **BORAX,** $Na_2B_4O_7.10H_2O$
- **BORAX 5 MOL,** $Na_2B_4O_7.5H_2O$
- **BORIC ACID,** H_3BO_3
- Anhydrous **RASORITE®** Sodium Borate Concentrates

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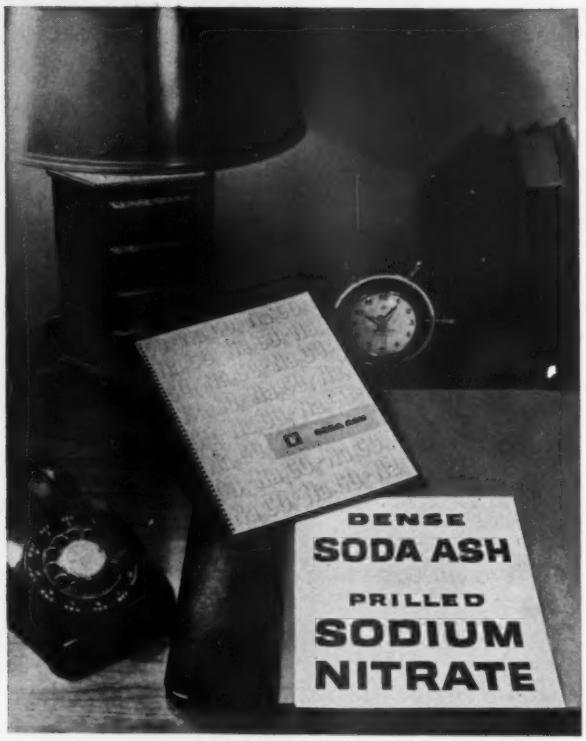

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(*Continued from page* 396)

2. An increase in the quantity of combustion air over the actual requirements results in a lower flame temperature.
3. Primary air premixed with fuel gas increases the flame temperature near the center of its length and reduces the end temperature.
4. An increase in the firing rate of fuel gas or oil without increasing premixing air or atomization medium will increase the emissivity of the flame. This may be accompanied with a decrease in flame temperature, effecting lower heat transfer which may be more than the heat transfer gain through emissivity change.

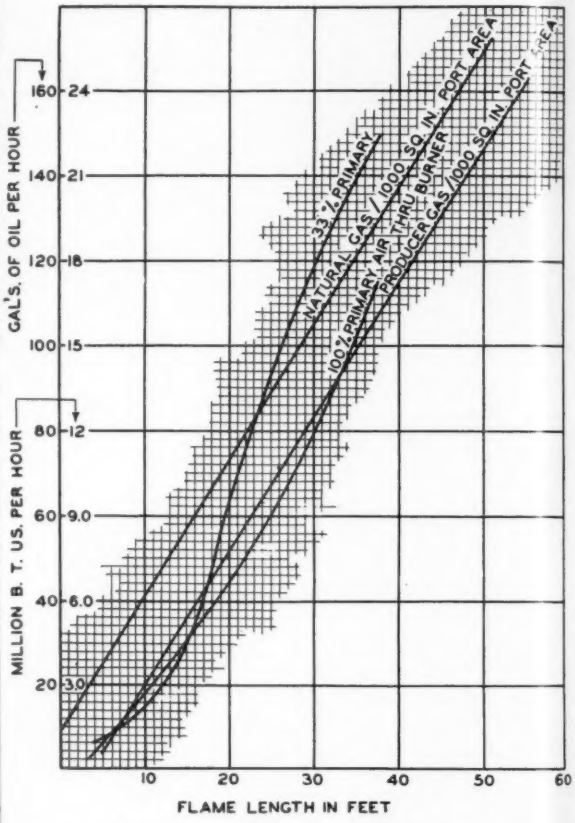

Fig. 6. Effect of Concentration of B.T.U.'s on Flame Length.

5. The use of steam as an atomizing medium for oil reduces the temperature of the flame along its entire length.
6. Flame temperature is higher at the burner when air is used in place of steam as the oil atomizing medium. The tail of the flame has a higher temperature where steam is used than when air is used.
7. An increase in the rate of the atomizing medium will increase the flame temperature midway its length and the tail end temperature will be reduced.

From the above, variations of quality or type affect the early part of the flame, while variations of quantity will affect the tail.

Flame gradient temperatures are not only affected by the combustion air preheat and the type or quality of the fire but are also influenced in the transfer of heat to work. To provide for the most economic application to obtain the desired heat transfer all these conditions should be considered.

In the application of some of the principles outlined above, consideration of the effect of the concentration of BTU's on flame length as shown by Fig. 6 is in order.

These curves indicate that for three fuels, natural gas, producer gas and oil, an increase in fuel rate results in the lengthening of the flame. Such information may be well adapted in selection of oil burners and in design of ports for application of gaseous fuels.

The adaptation of the variables mentioned, to obtain a desired condition, should include consideration of how the heat from a flame is transferred to the glass. Broadly speaking, 10 per cent of the transfer is by convection while the remaining 90 per cent can be attributed to transfer by radiation. The glass receives radiation directly from the flame and by reflection and radiation from the furnace crown.

Figure 7 shows the effect of heat transfer of interaction of flame and roof. It may be observed that with a flame having an emissivity of 50 per cent, the total heat transfer from flame and roof is approximately 73 per cent of the radiation from a 2900° F. black body. Of this total radiation, approximately 33 per cent is radiated from the roof.

CONCLUSION

The foregoing has covered many basic considerations which are familiar. However, with the increased production demand at lesser cost, their importance cannot be overstressed.

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Fig. 5 "Flame Temperature"—R. A. Sherman—Transaction of the American Society of Mechanical Engineers Page 182—1933.

Fig. 7 Effect on Heat Transfer of Interaction of Flame and Roof W. Trinks, Industrial and Engineering Chemistry Fig. 3, page 866, August 1933.

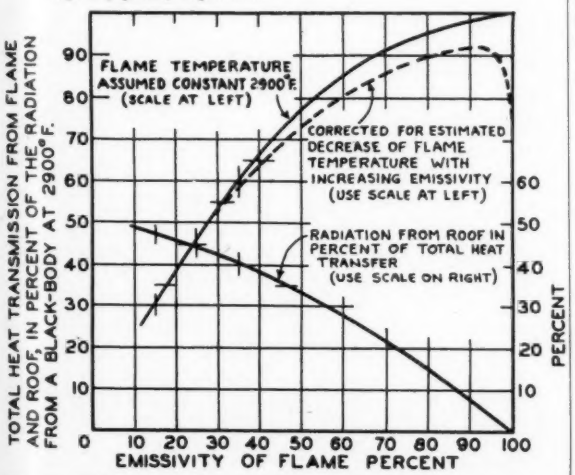
TOTAL HEAT TRANSMISSION FROM FLAME AND ROOF, IN PERCENT OF THE RADIATION FROM A BLACK-BODY AT 2900° F.
FLAME TEMPERATURE ASSUMED CONSTANT 2900°F (SCALE AT LEFT)
CORRECTED FOR ESTIMATED DECREASE OF FLAME TEMPERATURE WITH INCREASING EMISSIVITY (USE SCALE AT LEFT)
RADIATION FROM ROOF IN PERCENT OF TOTAL HEAT TRANSFER (USE SCALE ON RIGHT)
PERCENT
EMISSIVITY OF FLAME PERCENT
0 10 20 30 40 50 60 70 80 90 100
10 20 30 40 50 60 70 80 90

Fig. 7. Effect on Heat Transfer of Interaction of Flame and Roof. Calculated for these conditions: Flame Temperature, 2900°F.; Average Glass Temperature, 2300°F.; Area of Roof and Side Walls, 1.2 times Glass Bath Area; Convection, 2 B.T.U./Square Foot, Hour, °F.; Conduction Loss, 0.8 B.T.U./Square Foot, Hour, °F.; Roof Assumed to Have Practically Black-Body Emissivity.

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Calumite, in delivering these "extras", helps to eliminate the hidden costs in raw materials.

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NEW BUILDING FOR BRITISH RESEARCH

The British Glass Industry Research Association held a brief ceremony on May 30 at Sheffield, England, during which Dr. Lawrence Pilkington, Association chairman, laid the glass foundation "cornerstone" for the new Research building. It will have a floor area of about 19,000 square feet and will comprise an experimental furnace area, specialized laboratories and office accommodations. Expected completion date is late September of this year.

Having been formed in 1955, the British Glass Industry Research Association took over the industrial research, testing and consultative work previously carried out by the Department of Glass Technology of Sheffield University, so that the University could concentrate on educational and fundamental research work.

Both organizations have shared the same quarters since that time.

NEW PLANT FOR L.O.F. GLASS FIBERS

The new plant of L.O.F. Glass Fibers Company at Corona, Calif., will begin production on August 1, with a complete line of glass fiber insulation products, according to John A. Morgan, vice-president and general manager of the Pacific Coast division. This plant will engage in the basic manufacture of glass fibers.

Manufacturing will begin with the melting of marbles from which fine glass fibers will be drawn and blown by the firm's patented processes, finished into lightweight glass insulation materials, and then packaged and readied for shipment.

The Corona plant will be the company's seventh manufacturing facility in the United States. At present single-plant facilities are in Waterville, Ohio; Parkersburg, West Virginia; and Houston, Texas; and three facilities at Defiance, Ohio.

Inventions . . .

(*Continued from page* 388)

Similarly, citric acid works in concentrations from 0.005 per cent to 0.1 per cent or more.

Under similar conditions, 0.4 gram of phosphoric acid was used. The initial pH was 3.08 and the final pH, 4.35. Similarly, phosphoric acid works in concentrations from 0.01 per cent to 0.1 per cent or more.

There were 11 claims and the following references cited in this patent: Re. 2,491,761, Parker, Dec. 20, 1949; Re. 2,626, 214, Osborne, Jan. 20, 1953; Re. 2,658,848, Labino, Nov. 10, 1953; Re. 2,706,156, Arledter, Apr. 12, 1955.

Glass Wool and Fiber

Method for Producing a Continuous Roving. Patent No. 2,795,926. Filed February 23, 1954. Issued June 18, 1957. One sheet of drawings; none reproduced. Assigned to Owens-Corning Fiberglas Corporation by Warren Wendell Drummond.

This invention relates to a method for the production of a continuous multifilament roving comprising both continuous filaments and staple fibers intermatted and intertwisted together to produce a product having a high bulk factor and substantial tensile strength.

The continuous fibers are grouped together by being led over a gathering eye and then directed downwardly between the contacting peripheries of a pair of high speed pulling wheels. The pulling wheels apply tractive force to the mass of fibers in the form of a glass fiber strand. The pulling force applied by the wheels attenuates the fibers from the glass streams flowing from the bushing at a high lineal speed in the order, say, of 10,000 feet per minute, and projects the strand downwardly along a substantially lineal path.

A rotary spinner is so positioned that a plurality of axially extending pegs mounted near the edge of a rotating disk are repeatedly swung across the path of projection of the strand. The strand successively is engaged by each of the pegs, causing it to be formed into loops that are rotated around with the pegs on which they hang.

By controlling the speed of rotation of the spinner with respect to the lineal speed of the strand, the degree of "doubling up" of the strand on the pegs can be precisely controlled.

Staple glass fibers are added to the roving-like article during the time of intertwisting of the loops and of continuous strand.

It is, therefore, the principal object of this invention to provide a method for continuously producing a tough, strong twisted product in the nature of a strong cord, twine or roving.

There were five claims and the following references cited in this patent: 2,208,897, Dockerty et al., July 23, 1940; 2,719,350, Slayter et al., Oct. 4, 1955; 2,719.353, Slayter et al., Oct. 4, 1955, 2,743,573, Hiensch, May 1, 1956.

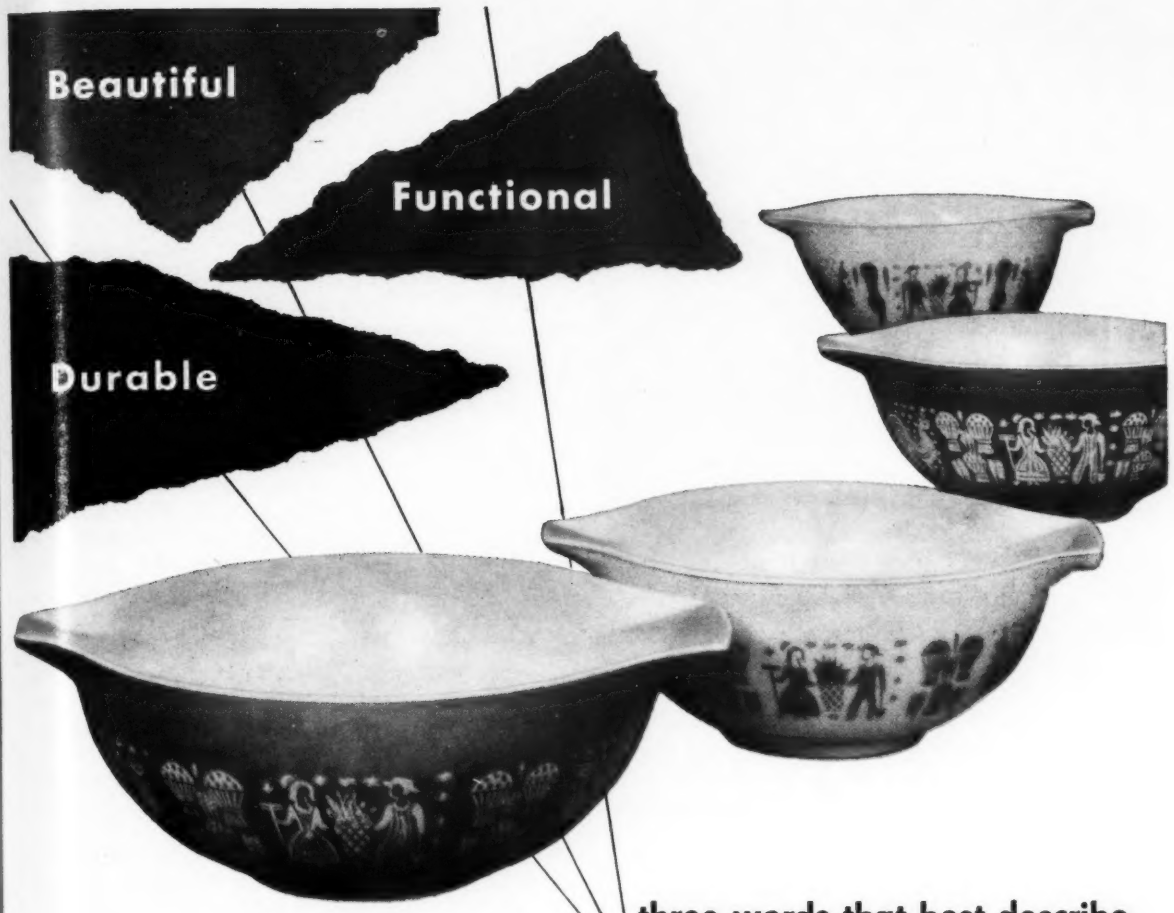
Method of Producing Fiber Glass Mats. Patent No. 2,794,237. Filed January 29, 1954. Issued June 4, 1957. Two sheets of drawings; none reproduced. Assigned to Fiber Glass Industries, Inc. by Ara T. Dildilian.

This invention relates to the manufacture of fiber glass mats providing a low density sheet of glass fibrous material consisting essentially of short strands of glass fibers in cut strand or staple form. The invention finds its principal use in the provision of re-enforcing materials for molded plastic structures, though the products of the invention are useful in various other applications with or without being incorporated in plastic media.

There is fed to the strand chopping device a rope of some hundreds of strands, each composed of many individual adhesively joined glass filaments. The strands are chopped into short lengths by the rotary cutter as they pass over the underlying firm rubber roll.

The cut, short, or staple lengths are discharged into the hopper of feeder which may be of the well known Bramwell type, including a spiked apron and stripper roll. The cut, staple-length bundles of fibers as so deposited lie primarily parallel to the faces of the bat, although they extend in random directions in any given plane parallel to the face of the bat. The bat is then carried along with the surfacing web through a conventional needling device. The needling device by means of its barbed needles draws some of the strands or portions thereof down through the bat of cut strands

(*Continued on page* 402)



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86-3

Milestones in Glass Progress

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1890 Michigan Alkali Company, now a division of Wyandotte Chemicals Corporation, was founded by Captain I. B. Ford to supply Soda Ash to the glass industry. Part of its modern Soda Ash facilities are huge, seven-story kilns (shown above), for roasting limestone. Wyandotte is a working partner, supplying technical assistance and raw-material chemicals to those great companies marking milestones in glass progress.

Wyandotte CHEMICALS

Michigan Alkali Division, Wyandotte Chemicals Corporation
Wyandotte, Michigan • Offices in principal cities

Founded by a Glassmaker to Serve the Glass Industry

(*Continued from page* 400)

and into or through the lower underlying web. From the rolls, the mat, with its attached surfacing material passes downward to be rolled as finished fabric.

Heretofore the manufacture of glass fiber mats of a thickness such that their weight exceeded 3 oz. per square foot, including a binding material, has not been commercially practicable. In actual practice, by means of this invention, glass mats have been made substantially in excess of that thickness which are entirely suitable for most plastic moulding operations, and this without the inclusion of a binding material. Furthermore, the manufacture of satisfactory mats of even greater thickness is possible by means of our invention, this being accomplished by feeding multiple plies of bat to the flared entrance of the needling device which are then united by the needling operation to thereby form an integral product.

There were seven claims and the following references cited in this patent: 2,158,533, Cavey, May 16, 1939; 2,339,431, Slayter, Jan. 18, 1944; 2,477,555, Roberts et al., July 26, 1949; 2,528,091, Slayter, Oct. 31, 1950; 2,584,702, Hogendobler, Feb. 5, 1952; and 2,639,759, Simison, May 26, 1953.

Fiber Glass Mat. Patent No. 2,794,238. Filed December 9,1952. Issued June 4, 1957. Two sheets of drawings; none reproduced. Assigned to Fiber Glass Industries, Inc., by Ara T. Dildilian and Kenneth M. Wood.

This invention concerns fiber glass mats providing a low density sheet of glass fibrous material consisting essentially of short strands of glass fibers in cut strand or staple form made by the procedure outlined in U. S. Patent No. 2,794,237, June 4, 1957, by Ara T. Dildilian and assigned to Fiber Glass Industries, Inc., Amsterdam, New York.

There was four claims and the following references cited in this patent: 2,339,431, Slayter, Jan. 18, 1944; 2,477,555, Roberts et al., July 26, 1949; 2,528,091, Slayter, Oct. 31, 1950; 2,584,702, Hogendobler, Feb. 5, 1952; 2,593,373, Weber, Apr. 15, 1952; 2,635,322, McDermott, Apr. 21, 1953; and 2,639,759, Simison, May 26, 1953.

Sheet and Plate Glass

Apparatus for Automatically Scoring and Cracking of Glass Sheets. Patent No. 2,793,471. Filed March 26, 1954. Issued May 28, 1957. Two sheets of drawings; none reproduced. Assigned to Asahi Glass Company, Ltd. by Motoharu Kurata and Sunao Shibata.

The object of the invention is to provide an apparatus by means of which there is obtained simply and at high efficiency, economically and with extraordinary speed, glass sheet sections of exact size.

Thus, sections of glass sheet having exact sizes may be obtained mechanically and extremely rapidly, by cracking off the glass sheet having been scored longitudinally and laterally.

This invention lies in an apparatus for automatically scoring glass sheet and then cracking off the scored sheet. Two beds are made to run alternately on guide rails intersected partly on the same plane outside or underneath the scoring table so as to make longitudinal

and transverse lines of scoring to the glass sheet to be cracked off. The scored glass sheet is broken apart by raising consecutively numerous longitudinal and transverse cracking off bars, or members having been housed as movable up and down in several rows of longitudinal and transverse grooves provided in the scoring table with a predetermined spacing to one another and intersecting partially always on the same plane with the said table. The cracking off bars are disposed below the scoring table and are actuated by several lifting rods.

There were seven claims and the following references cited in this patent.

United States Patents

1,140,143, Falvey, May 18, 1915; 1,167,254, Benson, Jan. 4, 1916; 1,972,210, Walron, Sept. 4, 1934.

Foreign Patent

290,241, Great Britain, Dec. 6, 1928.

Auto Glass Grinding and Edging Machines. Patent No. 2,790,271. Filed January 20, 1955. Issued April 30, 1957. One sheet of drawings; none reproduced. Assigned to Pilkington Brothers (Canada) Limited, by Walter O. Samson.

A new and useful grinding machine is described for grinding the edges of auto glass and the like. The machine comprises a combination of a water-tight casing having an open top and power-driven shaft extending between the side walls of the casing. The abrading wheel has its upper portion projecting through the open top of the casing, and a nozzle mounted in the front wall of the casing substantially at right angles to the shaft is adapted to deliver a stream of liquid perpendicularly against the periphery of the wheel.

A V-shaped clip secured to the upper edge of the rear wall of the casing and carrying a tapered sponge with a relatively narrow base portion and a wide head portion frictionally engages the periphery of the wheel and wipes the excess liquid from the edge of the glass. By providing a resilient grinding surface, splintering of the glass surface is avoided and therefore, more economical grinding is accomplished with less waste of glass.

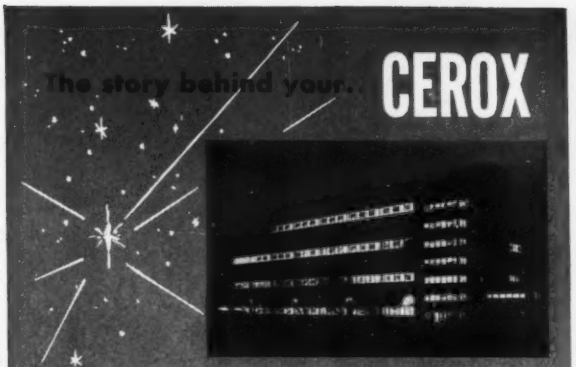
There was one claim, and 13 references, cited in this patent.

Grinding Machines Simultaneously Working Both Surfaces of a Continuous Ribbon of Glass. Patent No. 2,788,619. Filed September 10, 1954. Issued April 16, 1957. Four sheets of drawings. Assigned to Societe Anonyme des Manufactures des Glaces et Produits Chimiques de Saint Gobain, Chauny & Cirey by Robert Touvay.

This invention relates to apparatus for simultaneously grinding both faces of a continuous ribbon of glass.

A well known form of such apparatus is sometimes referred to as "the twin" and is characterized by the ribbon of glass being supported on the lower grinding elements as the ribbon is advanced between opposed series of upper and lower grinding elements.

By suitable adjustment of the level of the bottom discs, the working plane thereof is made to coincide constantly with the plane of the upper generatrices of the driving rollers on which the ribbon of glass rests, whatever the degree of wear on the discs.



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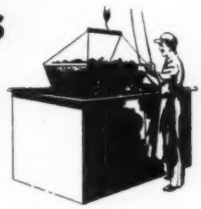

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As the grinding surfaces of the disc have the form of an annulus, the result is that the ribbon of glass is deprived of support in the central part of the disc, and also outside the latter in the triangular shaped areas between the outside edge of each disc and the nearest supporting rollers.

The main object of the present invention is to create a device to avoid deflection of the ribbon of glass in the areas where it has no support and is consequently subject to bending under the effect of its own weight, which bending may cause breakages of the ribbon of glass which are the more to be feared, the thinner the ribbon being subjected to the grinding operation.

Such breaks are produced in particular at the moment the ribbon of glass becomes engaged between two discs of one and the same pair, when the flat ribbon meets the virtually serrated annular grinding surface of the bottom disc either outside or inside this grinding surface.

In accordance with the present invention apparatus of the kind set forth for grinding a horizontally disposed ribbon of glass on both faces simultaneously is characterized by bottom grinder discs, within the central cavity of each of which is mounted a support for the ribbon constituted by a concentric ring at about the level of the plane containing the top generatrices of the associated glass supporting rollers for the strip-like zones of the ribbon which overlie the central cavities of the discs as the ribbon is advanced across the grinding surfaces of the discs.

There were 14 claims and 11 references cited in this patent.

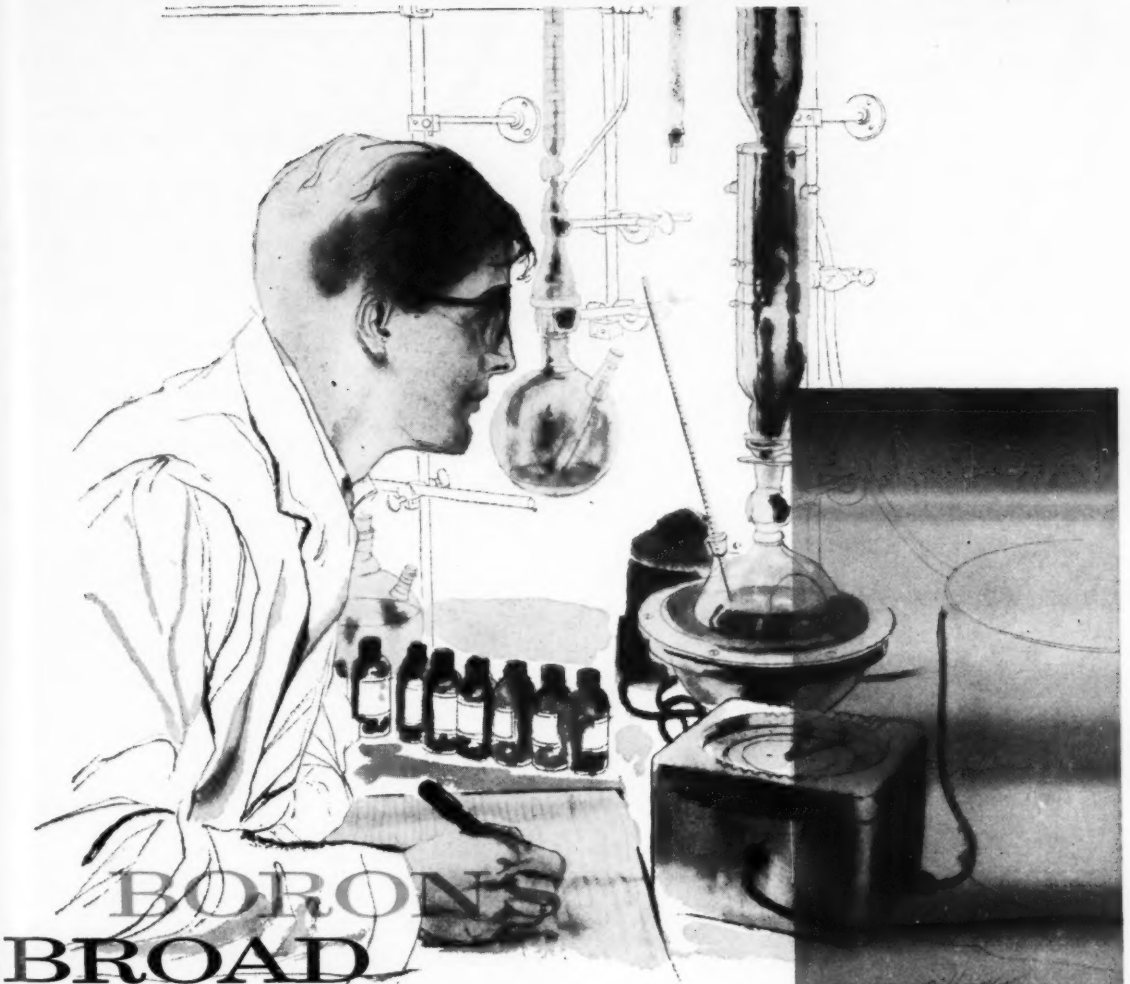
Tube and Cane Machines

Apparatus for wax coating scientific glassware. Patent No. 2,812,740. Filed October 4, 1954. Issued November 12, 1957. One sheet of drawings; none reproduced. Assigned to Owens-Illinois Glass Company by Walter E. Kirijan.

This invention is an improved method and apparatus for wax coating scientific glassware, such as pipettes, burettes and flasks. Permanent graduations ordinarily including lines and numbers are applied to scientific glassware by a procedure generally involving wax coating on the entire exterior surface. The ware is placed in a suitable numbering and lining machine which cuts through the wax coating and exposes the glass surface in the areas to be lined and numbered. After the wax has set, these articles are dipped into a bath of hydrofluoric acid which etches the exposed glass surfaces and permanently forms the lines and numbers, thereby providing the desired graduations. Incident to performance of the lining and numbering step, the articles are supported at their ends in holders or chucks which frequently score or chip the wax coating and expose glass surface which should not directly contact the hydrofluoric acid, for the obvious reason that such would result in undesired etching of the end portions of the articles.

A novel apparatus is provided in which the conventional "nail board" support for the tubes, after having tubes loosely positioned thereon, is dipped into a bath of liquid wax to coat, seal, and anchor one end of the

(*Continued on page* 406)



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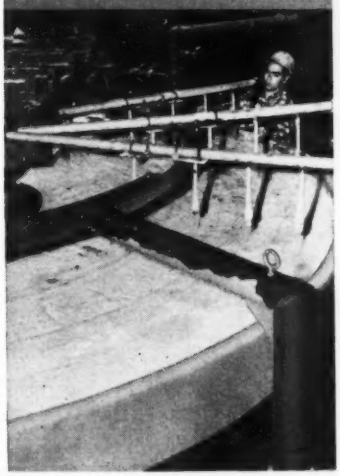

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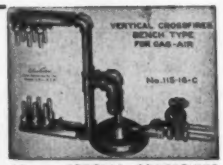

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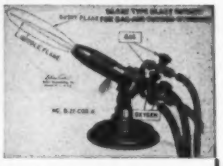

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(*Continued from page* 404)

tubes in the nail board. After the wax has set, such board is inverted and mechanically lowered to immerse the other end of the tubes in the wax bath to effect both sealing of the open end and coating of any scored portions.

The patent thus provides a novel method and apparatus for materially facilitating the so-called retouching operation and mechanizing the same, whereby the operator's efficiency and productive capacity may be very materially increased and a substantial saving in production costs effected.

There were two claims and the following references cited in this patent: 15,111, Howe et al., June 10, 1856; 599,865, Richards, Mar. 1, 1898; 709,369, Sondheim, Sept. 16, 1902; 968,791, Olsson, Aug. 30, 1910; 1,396,458, Ordine, Nov. 8, 1921; 1,594,375, O'Neil, Aug. 3, 1926; 1,638,445, Kavle, Aug. 9, 1927; 2,210,187, Ross, Aug. 6, 1940; 2,567,723, McCoy et al., Sept. 11, 1951; 2,651,284, Zinn et al., Sept. 8, 1953.

Miscellaneous Processes

Ultrasonic Cleaning of Curved Surfaces, and Apparatus for Cleaning. Patent No. 2,784,119. Filed September 17, 1953. Issued March 5, 1957. Two sheets of drawings. Assigned to Libbey-Owens-Ford Glass Company by William E. McCown and James W. McAuley.

The primary object of this invention is to provide a novel method of thoroughly cleaning sharply and complexly curved surfaces in a continuous manner, and a method that is ideally adapted for use on a factory production line.

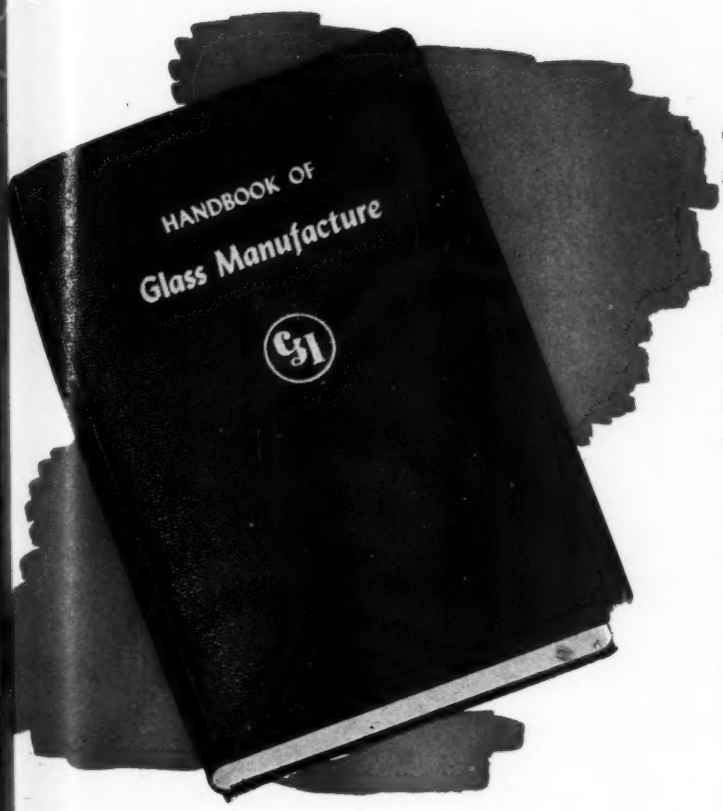
The vibration frequencies used are generally between 100 to 30,000 cycles per second and are transmitted in the form of mechanical vibration sound waves, through a suitable medium, for producing energy by means of which work is performed. Curved glass sheets or panoramic windshields are cleaned by continuously passing such glass articles through a bath of a suitable liquid medium and between generating elements which propagate vibrations within said medium in the ultrasonic range. These generating elements, which may be, for example, magnetostrictive transducers having a suitable output and frequency, are preferably arranged so as to direct the effect of said vibrations onto the glass sheets being moved between them along a path substantially normal to the surfaces. In this manner, the effect of said vibrations is maintained at a maximum over all points of said surfaces.

By moving the curved glass sheets continuously between the generating elements, there will be, in effect, a sweeping, washing action across both surfaces. Under this procedure, washing proceeds rapidly, and movement of the sheets concurrent with the washing action multiplies the speed of cleaning. Moreover, when the liquid medium into which said sheets are submerged during washing contains a detergent, the particles of foreign matter disintegrated upon the surfaces of the glass sheets may be even more quickly removed.

There were 8 claims and the following references cited in this patent: 2,484,014, Peterson, Oct. 11, 1949; 2,554,701, Hackett, May 29, 1951; and 2,609,826, Marvin, Sept. 9, 1952.

Again available

Handbook of Glass Manufacture



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